JOURNAL

OF THE

Department of Agriculture

OF

WESTERN AUSTRALIA.

Vol. 12. (Second Series) SEPTEMBER, 1935. No. 3.

TAKING THE MYSTERY OUT OF SILAGE MAKING.*

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Most farmers are familiar with the engine flywheel and know that its function is to equalise the driving effort of the engine. By means of the flywheel, energy is stored up during the periods of intermittent force applied to the piston, and thus power is provided to perform work during periods of stress and when the piston is not subject to any impelling force. In a similar way, because silage provides the means whereby the essential succulent food can be supplied to milch cows during periods when natural green pasture is absent, so it has been aptly stated that silage is the flywheel of the dairy farm.

Now just what is "silage"? Occasionally the words "silage," "ensilage" and "silo" are used indiscriminately and as having the same meaning. This, however, is not the case.

Silage is green forage—natural or cultivated—which has been conserved in a succulent form;

Ensilage is the process by which such forage is preserved by the exclusion of air, and

A silo is a trench, pit or building containing silage. Originally silo meant a pit or hole in the ground, but now implies any sort of receptacle above or below ground for storing or preserving any sort of agricultural produce and not necessarily only succulent fodder.

Though originally silage was made only in a pit, it is now also made in above-ground structures, in trenches or clamps below the ground, and in stacks. The most common and modern above-ground structures are known as "tower silos." They are cylindrical in shape and range from 20 to over 100 feet high.

To many farmers the process whereby green forage is converted into silage is at first astonishing. To them hay-making is simple and understandable; the green stuff is dried and it keeps, but the conservation of greenstuff in a succulent condition has an element of mystery about it. They know that damp partially cured hay, if stacked, is likely to burn, and therefore expect a mass of much greener and consequently damper material also to catch fire, particularly as the mass usually and quickly becomes very hot. Because of their experience with

* Published by courtesy of the Australian Broadcasting Commission, being an Agricultural Talk given through Station 6WF.

damp straw and stable manure, when it fails to burn, they expect it to rot, instead of which, when properly handled, it does neither. Apparently in some mysterious way it is preserved with all its succulence and food value, and retained in a form extremely palatable to stock, and on which they, particularly milking animals, do extremely well.

By consideration of what takes place when a mass of green foliage is put together, this apparent mystery can be removed from the making of silage. It is important that this should be done, for silage is such an important factor in a dairyman's success that any obstacle which stands in the way of the making of silage being a regular phase of his annual routine should be removed. There is really no reason why silage-making should not become as common-place as hay-making and cease to arouse any special comment. It is, however, advisable to understand what happens during the process and thus be in a position to secure best results.

It is generally recognised that the green plant attached to its root is a living organism, but it is not so well known that its plant cells will continue to live and breathe after the above-ground portion has been cut and separated from the roots. This, however, is so. When a number of newly cut green plants are placed together in a mass, this mass will become hot as the result of the breathing action of the still living plant cells, and the chemical changes resulting from bacterial activity. The degree of heat developed will depend upon the size of the heap of greenstuff, and to a large extent upon the amount of oxygen, as supplied by the air, available to the plants. The heat may become so great as to blacken and even char the plant issues. If the supply of air available to the plants is limited by pressure and in other ways, the plants will quickly die by suffocation and the rise in temperature will not be great. If the supply of air is plentiful the plants will live longer and the heat developed will eventually be great enough to kill the plant cells. The result in all cases is the same, that is, the plants are killed, and if no steps are taken to exclude the air then the material will either dry out or rot, but it does *not* burn as some would expect. One of the several reasons for the failure to burn is that the heat generated by the oxidation of the plant tissues is not great enough to reach the combustion point of the greenstuff.

The rotting which takes place in the absence of drying is caused by micro-organisms present in the air and on the green material, which, under moist and warm conditions, bring about putrefaction and decay.

If, however, the admission of air is prevented, as in the case of the silage stack by pressure, and in the case of the above-ground silo and pit by the impervious wall and facilities for settlement, the activities of the moulds and bacteria which cause decay are hindered or stopped, and those of another type of bacteria encouraged. The result of the work of the latter is that fermentation takes place, as in wine-making; but it proceeds a stage further and acids instead of alcohols are produced. These continue to be formed, mainly in the absence of air, until the amount of acidity present is equivalent to 1½ per cent. to 2 per cent. of the total mass of the material. When this concentration is reached their activity ceases and the acids present preserve or "pickle" the green forage, just as acetic acid, in the form of vinegar, preserves vegetables which, when so preserved, are known as "pickles." This explains why, as might be anticipated, the material does not rot. The same preserving or pickling effect could be obtained by spraying the material, as packed, with sulphuric or hydrochloric acid, and in fact such a plan is the basis of a method successfully adopted in Finland; it is known as the A.I.V. method, these being the initials of Arthuri I. Vertanen, the inventor of this process.

Because the preservation of silage is due to the presence of one or more acids, one of which very often is acetic acid, the chemical name for the acid in vinegar, all silage has an acid or sour taste. Some, but not all silage, has also a distinct acid smell; acetic and butyric acids are volatile and have characteristic smells, others like lactic acid—one of the most desirable acids found in silage—are not volatile and, therefore, have no smell. The presence of acetic acid is not detrimental, nor is its smell objectionable; it gives the distinctive title of acid to the silage in which it and related acids are in excess of the non-volatile acids. Butyric acid, however, has the very offensive smell of rancid butter, and though the stock may eat silage with this smell, such silage is inferior.

The kind of acid which is produced in the silage is governed by the presence or absence of air, *and* the temperature reached during the process. The bacteria responsible for the formation of butyric and lactic acid function in the absence of air, whilst the acetic and allied acids require air for their development. With regard to temperature, butyric acid bacteria work best at temperatures ranging from 95deg. to 105deg. F., and the acetic acid bacteria from 70deg. to 78deg., the lactic acid bacteria have a wider range commencing at the lower temperature of 48deg. and extending to 95deg. F. (Another type of lactic acid bacteria has a much higher range, viz., from 105deg. to 120deg. F.)

The presence of butyric acid, besides being objectionable, also indicates that the process of preservation has been defective and that the silage has been partially spoilt. It is, therefore, obviously desirable to prevent its formation. As it can be formed only when the temperature exceeds 95deg. F., it follows that strenuous efforts should be made to keep the temperature below that point; indeed it should be kept as low as possible, for reasons now to be stated.

The heating of the mass of green forage is only accomplished as the result of the oxidation or burning up of food material, such as the sugars and starches, just in the same way that the heat from a fire is produced by the destruction of fuel. Hence the greater the heat developed the greater the destruction and loss of food.

The heat generated in the mass is also responsible for loss due to the decomposition of the proteins. Though these are not destroyed, their value is considerably lessened, as in the altered condition they cannot be utilised by stock for building up new tissues and materials, such as the casein of milk, or for the repair of worn tissues for which true protein is alone suitable, and in consequence the resulting compounds are less valuable as food than the proteins from which they are derived. A further loss or waste caused by high temperatures occurs because the digestibility of the proteins is impaired thereby. On the other hand the digestibility of coarse fibre is improved, but the necessity for this is overcome by cutting early, *e.g.*, cutting cereals when in flower.

To minimise the rise in temperature it is necessary, firstly, to have the green material at as low a temperature as possible when placing it in the stack or silo, for even under the best conditions there will be a rise in temperature of at least 10deg. F., and secondly, as the rise in temperature is governed by the amount of air available, to limit this to the minimum.

If the work of building the stack or filling the silo is continuous, then in order to keep the temperature of the material as low as possible the herbage or crop should be stacked as it is cut—it must not be cut and allowed to wilt and warm up in the sun before being carted to the stack or silo. If, however, the work is intermittent, as is often the case, the crop being cut during one part of the day and the stacking or filling being done at a different time, then the cutting should take place

in the afternoon so that the material will, over night, be cooled down to the night temperatures, and it should be stacked in the morning before it has time to become warm.

The amount of air in the greenstuff available for oxidation, and consequent heating, is reduced by packing and pressure, and therefore the material should be thoroughly tramped as it is stacked or filled into the silo, and chaffing of the forage will assist materially.

To prevent deterioration of the preserved silage, the exclusion of air is essential. This depends, in the stack, upon the close packing and consolidation of the outside portions, and, in the silo, upon the impervious character of the walls and the manner in which they facilitate settlement of the mass. It may be questioned why it is necessary to exclude the air if the acid preserves the silage and the reason is that when air is admitted the acids are destroyed by moulds that feed upon them. When this takes place the bacteria that cause decay, known as putrefactive bacteria, attack the food material and spoil the silage.

There is quite a common belief that the process of ensilage increases the food value of the material from which the silage is made. This is not so, for the very fact of the silage becoming hot involves loss, as already explained, of the carbohydrates and proteins. Silage, even under the best conditions, has never the food value quite equal to the material from which it is made, though some of the products formed may stimulate milk production to a greater extent than the original food.

It will thus be seen that even though the animals may eat all the conserved material, there is always some loss or waste due to the lowered food value of some of it. As the loss is primarily due to the amount of air which is enclosed with the material when being ensiled, and later by the admission of air after conservation, then, as the air cannot as well be driven from the long material of a stack as from the chaffed material of a pit or silo, nor can the air be excluded as well from the open stack as from the enclosed pit or silo, it follows that in stack silage there will be the most waste. Consideration of the replacement of the stack by the almost equally cheap trench is essential in the dry areas, and desirable even in the wetter Southern areas.

It will be realised from what has been said that there is no need for any mystery to be attached to the making of silage.

Let me conclude, therefore, by summarising what long years of investigation have shown:—

1. That the crop or herbage for silage should be cut early, *e.g.*, cereals when in bloom;
2. The collected mass of greenstuff does not burn because the heat generated is not sufficient to reach the combustion point of the mass;
3. The silage does not rot because it is pickled or preserved by the acids which are self-formed as the result of bacterial activity; and
4. In order to insure minimum loss of food constituents the material should be as cool as possible when packed, and then packed by tramping to a maximum extent as quickly as possible.

ERRATUM.

Journal of Agriculture, Volume 12, No. 2, June, 1935, page 189, "Notes on Chemical Composition of Saltbushes from Salmon Gums Area"—"plants" in the second last line should read "animals."

AN INVESTIGATION OF THE TERRACE SOILS OF THE GASCOYNE RIVER AT CARNARVON.

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During the course of a visit to Carnarvon by one of the authors (L.J.H.T.) on August 19th and 20th, 1934, an inspection of those soils of the Gascoyne River, being developed for tropical agriculture, was arranged by the Director of Agriculture. The Tropical Adviser, Mr. G. B. Barnett, provided general information concerning the area and assisted in the taking of the soil samples.

Carnarvon is situated at the mouth of the Gascoyne River about 500 miles north of Perth, its geographic position being south latitude 24deg. 53min. and east longitude 113deg. 39min. 17sec. The climate is arid and subtropical (see Table 1), and is unsuitable for agriculture except under irrigation.

TABLE 1.

METEOROLOGICAL DATA OF CARNARVON.

(Information kindly supplied by the Divisional Meteorologist (Mr. E. B. Curlewis).)

Period.	Monthly Average.												Yearly Average.
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	
Average Rainfall (points)—1883–1933 (51 years) ...	38	75	70	62	155	256	167	68	25	13	4	17	950
No. of years in the 51-year period in which there was—													
(a) No rain	26	20	21	21	4	0	0	1	6	16	35	32	...
(b) 25 points or less ...	39	33	31	34	12	1	3	15	33	46	50	45	...
Monthly Temperatures—													
Mean Maxima ° F., 1898–1924 (27 years) ...	88·0	88·6	87·6	84·7	78·1	73·0	71·2	72·7	75·0	77·5	81·1	84·8	80·2
Mean Minima ° F., 1898–1924 (27 years) ...	71·3	72·1	70·7	65·4	58·1	53·6	51·3	52·8	56·8	60·4	65·0	68·3	62·2
Lowest Recorded ° F., 1898–1925 (28 years) ...	58·0	61·2	56·8	47·0	42·8	38·2	37·0	38·4	42·0	45·8	(Mean 50·4	71·2 58·0	° F.) ...
Mean Saturation Deficit—inches Hg	·44	·41	·42	·37	·27	·19	·17	·20	·27	·32	·35	·40	·31

Development for tropical agriculture began in earnest in 1933. Bananas and pineapples, with beans as a catch crop, are the chief crops and the early results are very encouraging. With liberal watering the Cavendish Banana has made phenomenal early growth and is promising satisfactory crops. The success of the hardy Cavendish species has led to experimentation with the Gros Michel variety this season in order to improve the product. Some description of the conditions at Carnarvon and the growth obtained is given by Wise (1930) in this "Journal."

The area surveyed for tropical agriculture is limited, amounting at present to 4,101 acres along the river frontages for a distance of about 12 miles from the mouth. (See Fig. 1.) The best soils appear to be confined to a strip along the river and the planters are making use of this advantage. Plantings have even been made satisfactorily on Crown land on the steep river banks, where inundation would be a danger in flood time, but where the soil conditions are suitable. Some of the plantations have been producing bananas for as long as four years, but most

of the plantings are from one to two years old. From results, there seems no doubt that the Cavendish variety of banana, as well as a variety of other tropical and subtropical crops, citrus, grapes, papaya, passion fruit, tomatoes, lucerne, etc., can be produced under irrigation with proper management.

The principal soils occur on a recent terrace which ranges from 12 to 30 feet above the present bed of the river and up to 20 feet above normal flood level. The river has cut a steep U-shaped valley through these deposits, probably as the result of a recent uplift along this portion of the coastline. (Jutson, 1934, p. 173). During much of the year, it is merely a sandy bed with intermittent pools, but the river comes down as a raging torrent on occasions following periodical heavy rains in the upper portions of the large drainage system. The terrace was probably laid down under these flood conditions but it is now generally above the known high water mark.

From observations made, the terrace consists of recent deposits of sands, often highly micaceous, and a limited amount of clay. Layers of river gravel and grit, and, in some cases, bands of clay are exposed in shallow wells up to 20 feet deep. The topography is relatively flat, and there is some evidence of the effect of wind action in modifying the surface soils. This is particularly apparent where the native vegetation has been destroyed by browsing animals such as camels, and more or less sterile wind swept patches occur. Wind erosion must be checked on account of the very strong winds and the susceptibility of the surface soils to deflation. The use of wind breaks to protect the plantations has been discussed by Wise (1930).

The permanent success of tropical agriculture depends, to a large extent, upon the establishment of a satisfactory system of irrigation, as water must be used practically throughout the year in normal circumstances, May, June and July being the only months of fairly reliable rainfall. The soils at present take the water very freely and the crops respond vigorously to the treatment. Drainage is good, and with the deep channel of the river in close proximity there should be no serious troubles with water logging of the principal soil types.

Irrigation is provided entirely by pumping from wells and bores, from pools in the river and from the river sands. Power is provided by combustion engines and by huge American pattern windmills. Mills with wheels up to 26 feet in diameter are used, but require a storage system as an insurance against calm weather. If the expense of reasonable water storage can be undertaken, wind power should be very satisfactory as Carnarvon is notoriously windy. The Divisional Meteorologist has supplied the figures given in Table 2 supporting this contention. It is to be noted that south-west winds prevail but southerly winds are important (afternoon recordings). Scott (1923) states that the most useful winds range in velocity from 9 to 22 miles per hour.

TABLE 2.

WIND VELOCITIES AT CARNARVON ESTIMATED AT 3 P.M. DAILY SHOWING PERCENTAGE OF OBSERVATIONS WHICH EXCEED 20 MILES PER HOUR.

WIND DIRECTION.	SUMMER.	AUTUMN.	WINTER.	SPRING.
	Dec., Jan., Feb.	March, April, May.	June, July, August.	Sept., Oct., Nov.
S.W. (Prevailing) ...	16 %	3 %	6 %	9 %
S.	22 %	4 %	5 %	18 %

Analysis shows that the irrigation water sampled at this time contains from 24 to 50 grains per gallon of dissolved solids (340 to 700 p.p.m.). The principal salt is sodium chloride, but there is generally present a considerable proportion of calcium which should minimise the solonising* effect of the sodium salts.

Wells are generally about 20 feet deep and the bores 50 to 60 feet deep. On account of the greater reserve, bores are preferred to wells, and if a very consider-

* Solonisation is a term used for the accumulation of sodium in the replaceable base fraction of the soil.

able amount of pumping becomes necessary, it is likely that the present shallow wells will have to be deepened. Pumping from the river sands and pools will be satisfactory until heavy floods interfere with the piping.

The present method of irrigation involves the flooding of a shallow channel, four or five feet wide, in which the banana stool is growing. This is done as frequently as weekly, depending on the appearance of the plants, and the lavish use of water leads to a humid tropical condition beneath the banana canopy which enables the bunches to develop normally.

THE VEGETATION OF THE TERRACE SOILS.

Under virgin conditions the vegetation of these soils consists principally of wattles (*Acacia* spp.), river gums (*Eucalyptus rostrata*), salt bushes (*Atriplex* spp. and *Rhagodia* spp.), and grasses, with more or less ephemeral herbage plants in season. The Acacias are of the green-leafed wattle type, in contrast with the grey-leafed Acacias of the mulga type growing further inland, and indicate a difference in the conditions under which they are growing. It is suggested that the difference is climatic and associated with the proximity to the coast, as general soil conditions, occurrence of ground water, etc., appear similar. The tempering effect of the coastal influences is, no doubt, a factor contributing to the success of the project in tropical agriculture.

THE SOILS.

The soils were examined on the North and South banks of the river and 37 samples were taken from 12 sites, generally to a depth of 42 inches, to represent the soils being developed for tropical agriculture. These resembled in some respects the soils of the Murray River, South Australia, rather than the Mulga zone soils typical of the Gascoyne area generally. Three principal groups of soils were recognised on the basis of the variations of the layers of sediments, as no mature profile was developed at any of the sites sampled.

Group 1.—Brown sands, with layers of finer sands, sandy loams and sharp sands.

Group 2.—Brown micaceous loamy sands and sandy loams, generally calcareous* in the subsoil.

Group 3.—Brown micaceous loams and sandy loams in layers, generally calcareous in the subsoil.

Group 3A.—Brown micaceous loams, layered with sandy loams, and often showing considerable surface erosion due to wind action.

Groups 2 and 3 appear to predominate in the planted areas, and are regarded as the most suitable for development, being permeable, loamy and free working. Group 1 is coarser in texture and responds less satisfactorily than Groups 2 and 3. Group 3A is relatively heavy and shows evidence of considerable surface erosion due to wind action, and some concentration of soluble salts. At the present time, vigorous cultivation will work this group of soils into a good tilth, the water is absorbed freely, and young bananas are growing vigorously. Group 3A is regarded as the least satisfactory of the soils examined and should be subjected to careful observation before being developed further.

The approximate positions of the sites sampled are shown in Fig. 1.

The soil samples were examined for various properties in the Government Chemical Laboratory with the following results:—

1.—*Mechanical Analysis.*

The International H_2O_2-HCl-NaOH method was used throughout, and the results of the analyses representing the several groups are expressed on the air-dry basis in Tables 3, 4, and 5.

* Determined by capacity to effervesce with dilute hydrochloric acid.

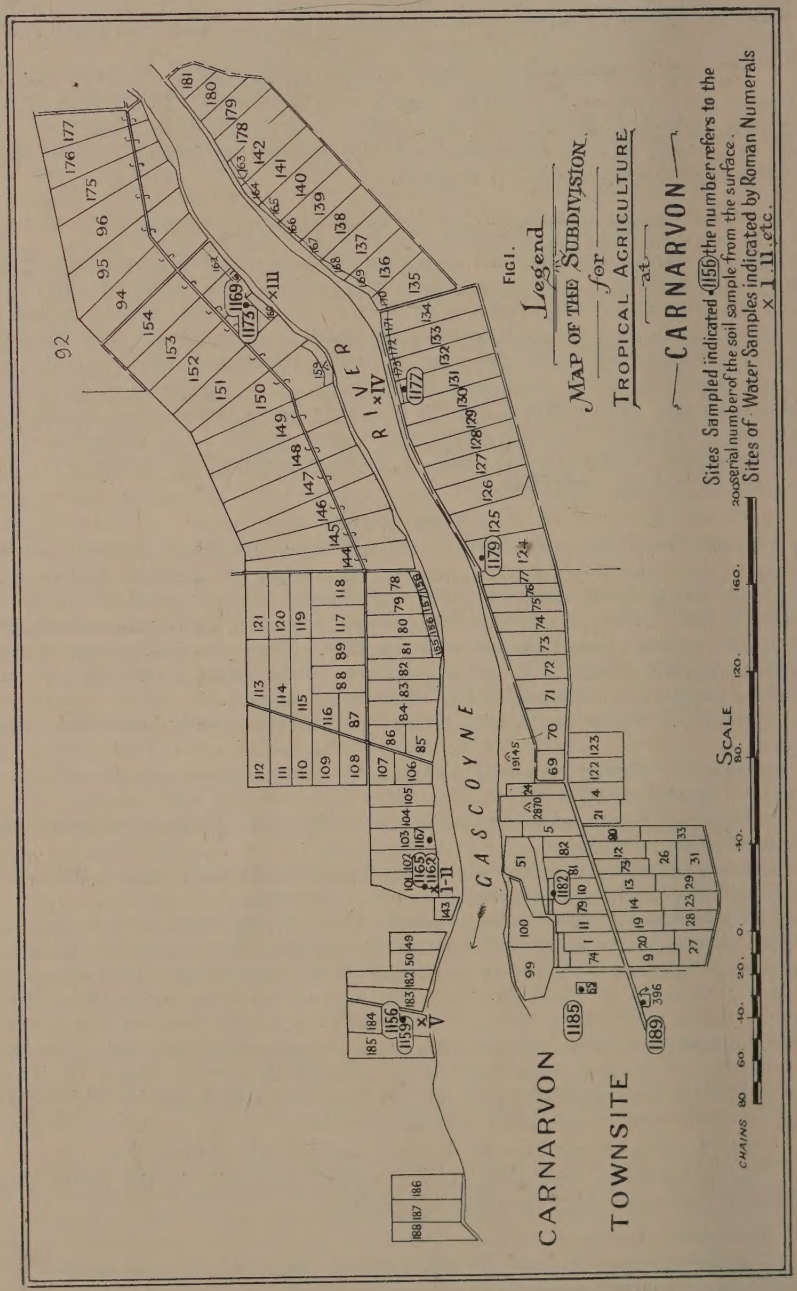
FIG. 1.
Legend
MAP OF THE SUBDIVISION
for
TROPICAL AGRICULTURE
at
CARNARVON
Sites Sampled indicated (156) the number refers to the consecutive number of the soil sample from the surface.
Sites of Water Samples indicated by Roman Numerals
x I. II. etc.
CASCOYNE
RIVER
CARNARVON
TOWNSITE
SCALE
CHAINS

TABLE 3.

MECHANICAL ANALYSIS OF SAMPLES FROM SITES 1 AND 2 REPRESENTING SOILS OF SOIL GROUP 1—THE LIGHTEST TEXTURED SOILS.

Site.	Loc. No.	Serial No.	Depth.	Coarse sand.	Fine sand.	Silt.	Clay.	Loss on acid treatment.	Moisture.	Loss on ignition.	Coarse sand fine sand ratio.	Field description.
			ins.	%	%	%	%	%	%	%	%	
1	184	1156	0–10	36·2	48·6	4·9	8·4	·8	0·8	2·4	·745	brown sand.
		1157	10–36	28·1	62·3	2·5	5·8	1·0	0·6	1·9	·451	brown fine sand.
		1158	36–42	59·3	31·9	2·8	5·7	·6	0·5	1·9	1·86	brown sharp sand.
2	184	1159	0–17	19·9	55·1	8·8	11·0	1·5	1·2	6·0	·361	brown loamy sand.
		1160	17–27	48·7	39·3	3·7	6·8	·9	0·6	2·4	1·24	brown sand.
		1161	27–42	61·3	29·9	2·7	5·4	·6	0·6	2·1	2·05	light brown sharp sand.

Analysts—F. F. ALLSOP.
G. E. M. DEAN.

TABLE 4.

MECHANICAL ANALYSIS OF SAMPLES FROM SITES 3 TO 10 INCLUSIVE, REPRESENTING SOIL GROUP 2 OF SANDY LOAM SOILS.

Site.	Loc. No.	Serial No.	Depth.	Coarse sand.	Fine sand.	Silt.	Clay.	Loss on acid treatment.	Moisture.	Loss on ignition.	Coarse sand fine sand ratio.	Field description.
			ins.	%	%	%	%	%	%	%	%	
3	101	1162	0·12	38·7	50·7	4·4	6·1	·5	0·4	1·9	·763	brown sand
		1163	12–33	16·8	52·2	13·6	16·2	1·1	1·4	3·8	·322	brown fine sandy loam, silty appearance
		1164	33–42	18·8	62·7	4·8	11·3	·8	1·2	2·8	·300	brown fine sand
5	103	1167	0–15	12·3	65·8	7·9	9·4	1·0	1·0	4·0	·187	dark brown micaceous loamy sand
		1168	15–42	2·5	66·5	11·6	16·2	1·0	1·8	4·0	·038	brown micaceous fine sandy loam
6	152	1169	0–12	8·6	72·3	5·8	11·0	·9	1·0	3·3	·119	brown sand
		1170	12–33	8·7	68·1	7·9	12·1	1·0	1·4	3·5	·128	brown loamy sand
		1171	33–38	9·9	63·2	8·8	14·5	1·5	1·6	3·9	·157	brown sandy loam
		1172	38–42	8·1	63·8	9·4	14·8	1·6	1·6	4·0	·127	brown loamy sand
7	152	1173	0–10	5·6	69·9	9·2	11·7	1·1	1·2	4·1	·080	dark brown micaceous sandy loam
		1174	10–22	6·5	72·4	6·6	11·8	1·7	1·1	4·1	·090	brown sandy loam, calcareous *
		1175	22–33	5·2	68·4	9·4	13·7	2·3	1·4	4·5	·076	light brown sandy loam, calcareous
		1176	33–42	7·7	63·5	11·1	15·1	2·1	1·5	4·4	·121	light brown loamy sand, calcareous
8	131	1177	0–10	6·3	74·3	6·4	10·7	1·1	0·9	3·9	·085	dark brown fine loamy sand
		1178	10–42	6·0	72·4	6·9	11·9	1·4	1·0	3·8	·083	brown micaceous fine loamy sand, calcareous
9	124	1179	0–12	17·6	54·9	11·5	12·8	1·5	1·4	5·0	·321	dark brown fine sandy loam
		1180	12–24	4·0	67·9	10·4	12·3	1·4	1·6	4·6	·059	brown sandy loam, calcareous
		1181	24–40	3·4	62·2	11·5	17·2	2·7	1·7	5·6	·055	brown loam, calcareous
10	10	1182	0–12	1·2	70·1	11·3	12·9	0·7	1·4	4·4	·017	brown fine sandy loam
		1183	12–36	1·4	70·4	9·8	15·1	0·5	1·8	4·2	·020	brown fine sandy loam
		1184	36–42	0·9	75·7	7·4	12·8	1·0	1·4	4·0	·012	brown fine loamy sand

* Effervescence with dilute hydrochloric acid.

Analysts—F. F. ALLSOP.
G. E. M. DEAN.

TABLE 5.

MECHANICAL ANALYSIS OF SAMPLES FROM SITES 11 AND 12, REPRESENTING SOIL GROUP 3—THE HEAVIEST TEXTURED SOILS.

Site.	Loc. No.	Serial No.	Depth.	Coarse sand.	Fine sand.	Silt.	Clay.	Loss on acid treatment.	Moisture.	Loss on ignition.	Coarse sand fine sand ratio.	Field description.
			ins.	%	%	%	%	%	%	%	%	
11 (Group 3)	65	1185	0–11	2·0	61·5	15·0	17·1	1·4	2·3	4·7	·033	brown loam to clay loam
		1186	11–20	1·3	54·1	17·1	23·0	0·9	2·4	4·5	·024	brown loam
		1187	20–27	1·8	65·5	11·0	16·6	1·1	2·1	4·2	·028	brown loam, calcareous
		1188	27–42	2·0	72·6	10·3	11·7	0·6	1·9	3·4	·028	brown sandy loam, calcareous
12 (Group 3A)	396	1189	0–10	1·7	59·3	15·9	17·5	2·2	2·4	5·5	·029	dark brown clay loam
		1190	10–15	1·7	56·8	15·4	18·3	2·3	3·6	5·6	·030	brown clay loam, calcareous
		1191	15–26	2·6	55·3	16·2	22·8	2·0	2·5	4·8	·047	brown light clay loam, calcareous
		1192	26–42	2·4	67·3	6·2	21·4	1·5	1·8	3·7	·036	brown sandy loam to loam

Analysts—F. F. ALLSOP.
G. E. M. DEAN.

The mechanical composition of the soil shows that there is no systematic profile development apparent, and that the variations are adventitious, being due principally to bedding resulting from deposition during successive flood periods. At least three distinct grades of material have been laid down in the superficial layers (to a depth of 42 inches):

1. Coarse sand predominating and clay fraction low. This is represented by soils in Group 1, in the north-west portion of the area.

2. Fine micaceous sand predominating, being about 10 times as abundant as the coarse sand fraction, with clay to the extent of 10 to 16 per cent. This grade appears to predominate in the area developed for agriculture and is represented principally by the soils of Group 2.

3. Fine sand predominating, being about 30 times as abundant as the coarse sand fraction, with clay to the extent of 12 to 23 per cent. This grade of material is most important in soil Group 3.

The textural relationship between these groups of soils is illustrated in the distribution triangle in Figure 2.

Features of the soils generally are the predominance of the fine sand fraction and the occurrence of a considerable amount of mica which appears to contribute to the friability which is characteristic of the soils.

2.—*Chemical Analysis.*

The soils were examined for general chemical properties and replaceable bases, using standard methods of analysis. The results are reported on the basis of the oven-dry soil, and the tabulations are made according to chemical properties and not to soil group as in the case of the mechanical analyses.

All samples were examined for calcium carbonate, total water soluble salts and reaction, the latter being determined by the quinhydrone method using a soil water ratio of 1:2.5. A selected number of samples, representative of the several soil conditions, were examined for nitrogen, and organic carbon, for phosphoric oxide and potash soluble in concentrated hydrochloric acid and in one per cent. citric acid, and for replaceable bases. The results are given in Tables 6, 7, and 8.

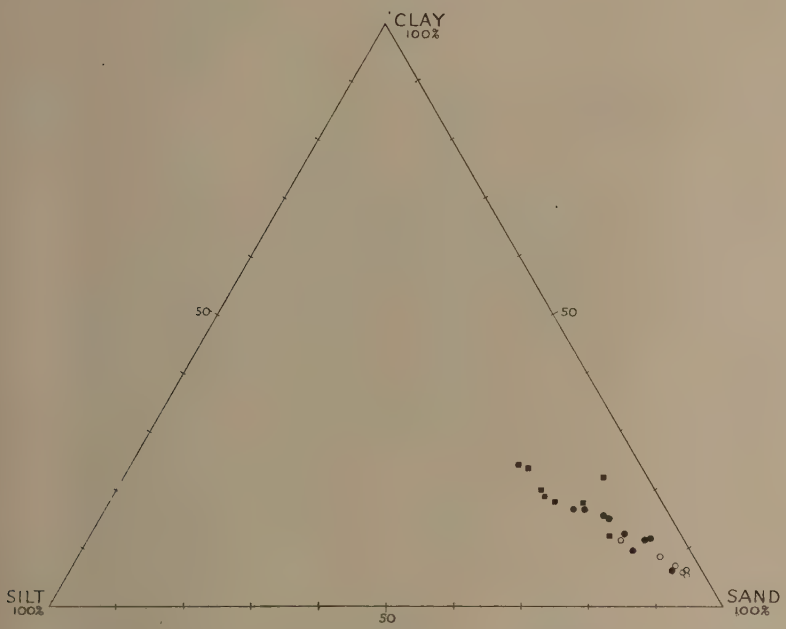

FIG. 2 DISTRIBUTION TRIANGLE SHOWING THE TEXTURAL RELATIONSHIP BETWEEN THE SOILS OF THE DIFFERENT GROUPS EXAMINED

GROUP 1 ∘
GROUP 2 •
GROUP 3 ▪

Note.—The triangle method of representing the mechanical composition of soils is based upon the classification of the soil grains or particles into three main groups: sand, silt and clay. When the three apices of the triangle represent 100 per cent. of sand, silt and clay respectively and zero per cent. of the other two portions any combination can be shown on the diagram as a point. Thus a soil containing 50 per cent. sand, 30 per cent. clay and 20 per cent. silt will be represented by a point on the line joining the 50 per cent. marks on the sand-silt base and sand-clay base. It will also be represented by a point on the line joining the 30 per cent. marks on the clay-sand and clay-silt bases. The intersection of these lines is therefore the point which represents the mechanical analysis of the soil. The line plotting the 20 per cent. silt fraction also passes through this point. The position of this point shows clearly the relationship of the mechanical analyses under comparison. In this case the samples representing soil Groups 1, 2 and 3 are distributed in groups on the triangle, which shows both the relationship between the samples in each soil group and the relationship between the soil groups.

TABLE 6.

RESULTS OF ANALYSIS OF SOILS FOR pH, CALCIUM CARBONATE, WATER SOLUBLE SALTS, AND CHLORIDES—OVEN DRY BASIS.

Site.	Soil Group.	Loc. No.	Serial No.	Depth.	pH	$CaCO_3$	Water Soluble Salts	NaCl from Cl	Ratio NaCl water sol. salts.
				ins.		%	%	%	
1	1	184	1156	0–10	8·27	0·25	0·108	0·026	0·241
			1157	10–36	8·34	0·09	0·069	0·026	0·377
			1158	36–42	8·34	0·09	0·054	0·018	0·333
2	1	184	1159	0–17	7·51	0·16	0·226	0·041	0·182
			1160	17–27	7·94	0·14	0·057	0·015	0·263
			1161	27–42	8·59	0·18	0·049	0·010	0·204
3	2	101	1162	0–12	8·12	0·09	0·049	0·007	0·143
			1163	12–33	7·94	0·02	0·064	0·021	0·328
			1164	33–42	8·32	0·05	0·066	0·012	0·182
4	2	101	1165	crust	8·00	0·16	0·057	0·009	0·158
			1166	0–6	8·16	0·11	0·047	0·015	0·319
5	2	103	1167	0–15	7·99	0·09	0·161	0·054	0·336
			1168	15–42	8·42	0·33	0·083	0·022	0·265
6	2	152	1169	0–12	8·49	0·09	0·096	0·004	0·042
			1170	12–33	8·59	0·47	0·074	0·010	0·135
			1171	33–38	8·59	0·71	0·082	0·011	0·134
			1172	38–42	8·68	0·85	0·073	0·012	0·164
7	2	152	1173	0–10	8·30	0·18	0·070	0·006	0·086
			1174	10–22	8·37	0·49	0·046	0·006	0·130
			1175	22–33	8·46	1·36	0·054	0·009	0·167
			1176	33–42	8·57	1·09	0·053	0·006	0·113
8	2	131	1177	0–10	8·17	0·09	0·064	0·008	0·125
			1178	10–42	8·48	0·33	0·070	0·016	0·229
9	2	124	1179	0–12	8·03	0·20	0·102	0·012	0·118
			1180	12–24	8·54	0·47	0·086	0·009	0·105
			1181	24–40	8·56	0·19	0·077	0·007	0·091
10	2	10	1182	0–12	8·07	0·94	0·082	0·033	0·402
			1183	12–36	7·51	0·07	0·100	0·046	0·460
			1184	36–42	7·67	0·14	0·068	0·036	0·530
11	3	65	1185	0–11	7·82	0·09	0·245	0·118	0·482
			1186	11–20	8·10	0·16	0·163	0·071	0·435
			1187	20–27	8·03	0·25	0·233	0·053	0·227
			1188	27–42	8·02	0·11	0·125	0·061	0·488
12	3A	396	1189	0–10	7·26	0·09	1·340	0·800	0·597
			1190	10–15	7·57	0·18	1·792	1·313	0·732
			1191	15–26	7·91	0·55	1·685	1·109	0·658
			1192	27–42	8·19	0·16	1·400	0·586	0·418

Analysts: B. L. Southern.
G. E. M. Dean.

TABLE 7.

RESULTS OF ANALYSIS OF SELECTED SOILS FOR ORGANIC CARBON, NITROGEN, POTASH AND PHOSPHORIC OXIDE, EXPRESSED AS PERCENTAGES IN OVEN-DRY SOIL.

Site.	Soil Group	Loc. No.	Serial No.	Depth	Hydrochloric Acid Soluble.		Citric Acid Soluble (available) K_2O	Ratio available K_2O	Replaceable Potash K_2O	Organic Carbon.	Total Nitrogen.	Ratio C : N
					P_2O_5	K_2O		Acid Soluble K_2O				
				ins.	%	%	%		%	%	%	
1	1	184	1156	0–10	...	...	...	...	...	0·42	0·032	13·1
			1157	10–36	...	...	...	...	...	0·11	0·010	11·0
2	1	184	1159	0–17	0·082	0·438	0·065	0·149	...	1·61	0·134	12·0
			1160	17–27	0·049	0·259	0·030	0·116	...	0·36	0·027	13·3
			1161	27–42	0·042	0·212	0·033	0·156	...	...	...	...
3	2	101	1162	0–12	...	...	...	...	...	0·14	0·015	9·3
			1163	12–33	...	...	...	...	·028	0·21	0·020	10·5
5	2	103	1167	0–15	0·098	0·500	0·106	0·212	...	0·72	0·064	11·2
			1168	15–42	0·088	0·588	0·038	0·065	...	0·27	0·028	9·6
6	2	152	1169	0–12	...	...	...	...	...	0·34	0·034	10·0
			1170	12–33	...	...	...	...	...	0·25	0·024	10·4
7	2	152	1173	0–10	0·126	0·528	0·051	0·097	·064	0·60	0·060	10·0
			1174	10–22	0·115	0·457	0·034	0·074	·037	0·29	0·034	8·5
8	2	131	1177	0–10	0·128	0·404	0·028	0·069	·034	0·64	0·063	10·2
			1178	10–42	0·089	0·458	0·054	0·118	·053	0·32	0·028	11·4
9	2	124	1179	0–12	0·096	0·578	0·084	0·145	·099	0·65	0·074	8·8
			1180	12–24	0·079	0·696	0·111	0·160	·147	0·37	0·043	8·6
			1181	24–40	0·092	0·715	0·096	0·134	·110	...	...	...
10	2	10	1182	0–12	...	...	...	...	...	0·31	0·043	7·2
			1183	12–36	...	...	...	...	...	0·23	0·026	8·8
11	3	65	1185	0–11	0·088	0·662	0·058	0·088	·086	0·56	0·058	9·7
			1186	11–20	0·045	0·658	0·044	0·067	·061	0·30	0·037	8·1
			1187	20 27	0·061	0·572	0·035	0·061	...	...	...	...
12	3A	396	1189	0–10	0·111	0·689	0·087	0·126	·099	1·14	0·076	15·0
			1190	10–15	0·096	0·778	0·090	0·116	·106	0·65	0·055	11·8
			1191	15–26	0·079	0·684	0·075	0·109	...	...	...	...
			Mean		...	...	...	0·115	...	...	...	10·4

Analyst: B. L. Southern.

TABLE 8.

REPLACEABLE BASES OF SAMPLES OF SOIL SELECTED TO REPRESENT THE AREA INVESTIGATED. RESULTS CALCULATED TO OVEN-DRY BASIS.

Site.	Soil Group.	Location No.	Serial No.	Depth Ins.	Milli-equivalents per 100 grams of soil					Percentage of total bases.			
					Ca	Mg	K	Na	Total	Ca	Mg	K	Na
										%	%	%	%
3	2	101	1163	12–33	7·19	3·04	·59	·41	11·23	64	27	5	4
7	2	152	1173	0–10	13·70	2·19	1·36	·34	17·59	78	12	8	2
			1174	10–22	7·98	1·55	·79	·37	10·69	75	14	7	4
8	2	131	1177	0–10	5·94	3·90	·73	·58	11·15	53	35	7	5
			1178	10–42	5·64	2·82	1·13	·98	10·57	53	27	11	9
9	2	124	1179	0–12	8·64	5·23	2·11	·55	16·53	52	32	13	3
			1180	12–24	4·37	2·62	3·13	·47	10·59	41	25	30	4
			1181	24–40	6·56	1·40	2·34	·61	10·91	60	13	21	6
11	3	65	1185	0–11	8·81	·74	1·82	·73	12·10	73	6	15	6
			1186	11–20	9·63	2·58	1·30	·38	13·89	69	19	9	3
12	3A	396	1189	0–10	13·47	6·26	2·11	·88	22·72	59	28	9	4
			1190	10–15	13·88	3·89	2·25	1·57	21·59	65	18	10	7
									Means	62	21	12	5

Analysts—B. L. SOUTHERN.
F. F. ALLSOP.

In conformity with the low rainfall conditions prevailing, all samples proved to be distinctly alkaline in reaction. On the other hand, water soluble salts are generally very low, and sodium chloride forms but a small fraction of the total water soluble material, resembling in these respects the soils of higher rainfall areas. This is apparently due to the fact that the soils are immature and the deposits of recent origin. Where accumulation of salts has taken place, as at site 12, the common salt fraction is very considerable, amounting to from 40 to 70 per cent. of the water soluble material.

Calcium carbonate is generally present in small but definite quantities although soil development has not yet proceeded sufficiently to give any considerable calcium carbonate accumulations in the subsoils as in normal, mature pedocals. As pineapples are generally recognised to prefer an acid soil, which would be free of calcium carbonate (Henrickson, 1925, and Lewcock, 1935), it will be important to observe their reaction to the alkaline Gascoyne soils.

Plant food constituents are relatively generously supplied and availability is high.

The dry conditions are not conducive to nitrogen accumulations and this constituent ranges from 0.01 to 0.134 per cent. According to Hilgard's standards, the soils would be classed as generally poor to medium with respect to nitrogen; organic matter, as measured by organic carbon, shows a similar relationship. It will be the task of the planters to build up the organic matter fraction of the soil in the course of their farming operations by the incorporation of trash, the growth of cover crops, etc. It is interesting to note that the C:N ratio averages 10.4 in this group of soils. Wider ratios are common in Australian soils.

Phosphate is abundant when compared with other Australian samples. According to Hilgard's standard, these soils would be classed as medium with respect to phosphate.

The soils are rich in potash, and in this respect compare satisfactorily with those of the Murray River Valley which have been described in current C.S.I.R. Bulletins. Furthermore, the availability of the potash is high. The citric acid soluble fraction averages 11.5 per cent. of the figure for potash soluble in concentrated hydrochloric acid. The range is from 6 to 20 per cent. The replaceable potash, also, is high and is generally somewhat higher than the citric acid soluble fraction. Martin (1929) has shown that crops draw largely upon the replaceable potash fraction of Californian soils of a similar climatic group. Magistad (1934) has studied the relationship between replaceable potash and the response of pineapples to potash fertilisers in the Hawaiian Islands, and concludes that no response would be expected on a soil containing more than 0.50 milligram equivalents of potash per 100 gm. soil. Recommendations for the use of potash fertilisers have been made on this basis in the pineapple plantations of the Hawaiian Islands.

The results obtained for replaceable potash in this investigation suggest that the Gascoyne soils should exhibit no deficiency of potash under proper soil management.

Of very considerable interest is the information concerning the replaceable bases of these soils. Analysis shows that the fraction consists principally of calcium, which averages 62 per cent. of the total replaceable bases in the soils examined. Magnesium and potassium form quite important proportions in certain instances.

Sodium is invariably low, averaging less than 5 per cent. and not exceeding 9 per cent. of the total replaceable bases in any of the 12 samples examined. Solonisation of the soils has not occurred, and in this respect they differ from the mature soils examined in other portions of the pedocal region of Australia. The work of Prescott and his co-workers in the Eastern States and the results of analyses made in this State show that soils of this region, and more particularly in the Mallee zone, are generally rich in replaceable magnesium and sodium with calcium and potassium less abundant.

By comparison, the Gascoyne soils resemble more closely in this respect the soils of North America and Europe described by Kelley, Hissink, Gedroiz and others, and certain soils of Queensland described by Prescott (1931). From the point of view of permanent irrigation this predominance of calcium in the replaceable base fraction is distinctly encouraging, as calcium soils generally maintain their structure and are more suitable for irrigation than soils rich in the univalents, especially sodium.

By way of comparison with the present work, the results of analyses of 6 samples of soil taken by Mr. A. K. Scott, Irrigation Expert, of the Department of Agriculture, from the neighbourhood of Carnarvon, in July, 1919, are given in Table 9.

TABLE 9.

ANALYSES OF SOILS FROM THE CARNARVON AREA.

Sampled by A. H. Scott, July, 1919.

Location.	Depth. Inches.	Moisture.	Loss on Ignition.	Nitrogen.	Hydrochloric acid soluble			Citric acid soluble availability.		Sodium Chloride from Chloride.	Reaction to litmus.
					CaO	P_2O_5	K_2O	P_2O_5	K_2O		
Doorawarrah Station, 50 miles E. of Carnarvon, 5 chains S. of river	0–10	1·56	2·35	·022	·164	·035	·312	·005	·027	·003	Slightly Alkaline.
Do. do. ...	10–20	1·94	2·22	·028	·230	·030	·320	...	...	·005	do.
Between Doogalilla and Myrandie, 20 miles E. of Carnarvon, 1 mile S. of river	0–10	3·83	4·77	·039	·260	·063	·335	·013	·049	·250	do.
Do. do. ...	10–20	4·13	5·40	·034	·420	·055	·329	...	...	·560	do.
Young's property, Yankeetown, 3 miles from Carnarvon; river south about ½ mile	0–10	2·77	8·00	·129	1·11	·126	·332	·049	·040	·330	do.
Do. do. ...	10–20	2·33	6·20	·070	·260	·103	·338	...	...	·132	do.

Analysts—S. C. PALMER. and B. L. SOUTHERN.

THE IRRIGATION WATER.

Five samples of water used for irrigation purposes were collected by Mr. Barnett, and have been submitted to the usual chemical examination. Samples from Locations 101, 131, and 152 were collected during the first week of September, 1934, and that from Location 184 during the first week of October. The results are given in Table 10.

TABLE 10.

ANALYSIS OF IRRIGATION WATER USED FOR BANANA CULTURE AT CARNARVON.
Sampled by G. B. Barnett, Tropical Adviser.

Sample ...	I.		II.		III.		IV.		V.	
Location ...	101		101		152		131		184	
Date Sampled	Sept., 1934.		Sept., 1934.		Sept., 1934.		Sept., 1934.		Oct., 1934.	
Supply ...	Well.		Bore.		River Sand.		Pool in River.		Well.	
Depth	23 feet.		64 feet.		3 feet.		—		19 feet.	
	ppm.	grains per gallon.	ppm.	grains per gallon.	ppm.	grains per gallon.	ppm.	grains per gallon.	ppm.	grains per gallon.
Conventional Salt—										
$CaCO_3$ ...	38	2·66	35	2·45	75	5·25	80	5·60	80	5·60
$CaSO_4$ ...	...	...	...	...	85	5·95	41	2·87	...	...
$MgCO_3$ ...	35	2·45	42	2·94	...	...	...	...	55	3·85
$MgSO_4$ ...	...	...	...	...	78	5·46	91	6·37	20	1·40
$MgCl_2$ ...	...	...	...	...	47	3·29	27	1·89	...	...
K_2SO_4 ...	54	3·78	54	3·78	...	...	...	...	...	...
KCl ...	...	...	...	...	25	1·75	10	0·70	23	1·61
Na_2CO_3* ...	90	6·30	80	5·60	...	...	...	...	...	...
$NaNO_3$ ...	3	0·21	3	0·21	1	0·07	1	0·07	8	0·56
Na_2SO_4 ...	58	4·06	47	3·29	...	...	...	...	22	1·54
NaCl ...	425	29·75	401	28·07	385	26·95	326	22·82	127	8·89
$Fe_2O_3 + Al_2O_3$	9	0·63	*nil*	*nil*	1	0·07	7	0·49	6	0·42
SiO_2 ...	8	0·56	15	1·05	3	0·21	9	0·63	4	0·28
Total ...	720	50·40	677	47·39	700	49·00	592	41·44	345	24·15
Total hardness (calculated) ...	79	5·53	84	5·88	252	17·64	213	14·91	162	11·34
Ratio $\frac{NaCl}{\text{Total dissolved solids}}$	0·59		0·59		0·55		0·55		0·37	
	ppm.		ppm.		ppm.		ppm.		ppm.	
Ions—Cl	258		243		281		223		88	
HCO_3 ...	201		195		92		98		177	
SO_4	69		62		122		102		31	
NO_3 ...	2		2		1		1		6	
Ca	15		14		55		44		32	
Mg	10		12		28		25		20	
K	24		24		13		5		12	
Na	226		209		151		128		59	
Ratio $\frac{Na}{Ca}$ (by weight)	15·1		14·9		2·75		2·91		1·84	
pH	7·0		7·1		6·7		6·9		7·3	

* This will occur in the fresh water as $NaHCO_3$ with the ions HCO_3 and CO_3 in equilibrium.

Analyst: F. W. Steel.

While the concentration of water soluble salts exceeds that of the most desirable irrigation waters (the Murray River water contains from 5 to 7 grains per gallon of dissolved solids), it is within the range recognised as satisfactory. (The upper limit of this range is usually accepted as from 70 to 100 grains per gallon, although no hard and fast rule can be made.) When the properties of the Carnarvon soils are considered, permeability, drainage, and chemical properties, it seems likely that waters similar to those analysed will be quite suitable for irrigation purposes. The least satisfactory of these samples are from the well and bore on Location 101, which waters contain a little sodium bicarbonate and the ratio of sodium to calcium is much wider than in the other samples. However, with the judicious soil management it is unlikely that any serious consequence will follow the use of these waters.

It is known, however, that brackish and slightly brackish water is obtained in the irrigation area, and care must be exercised in the selecting of sites of wells and bores for irrigation purposes. This is borne out by the analysis of samples of water collected in the district by Mr. A. H. Scott, in July, 1919, and examined for chloride content in the Government Chemical Laboratory. The results are given in Table 11. The sample from the well on Mr. Young's property at Yankeetown, and in the irrigation area, is high, and the result suggests that caution must be exercised in the use of water in this neighbourhood. Chemical analysis of doubtful samples would be advisable before equipment for irrigation is erected.

TABLE 11.

SODIUM CHLORIDE CONTENT OF WATERS FROM THE CARNARVON DISTRICT.

Samples collected by A. H. Scott, Irrigation Expert, July, 1919.

Locality.	Sodium chloride (calculated from chloride). Grains per gallon.
Well, 35ft. deep, near Gascoyne River, at Doorawarrah Station, 50 miles from Carnarvon	30·5
From rocky pool about 34 miles from Carnarvon	48·5
Young's property, Yankeetown, well 18ft. deep	136·8

Analyst—F. E. CHAPMAN.

In using the water it is advisable to use minimum quantities, as too lavish application is costly from the point of view of both power consumption and soil management. It is a fundamental principle, however, that sufficient water, more particularly when highly charged with salts, must be used to cause a certain amount of drainage with the object of removing any accumulations of deleterious salts. Plants feed selectively—they do not absorb the water and its soluble matter as a unit as would a pump, but take up some ions more vigorously than others and with no simple relation to water intake. Sodium and chloride ions, which are most abundant in the irrigation water are not absorbed freely, and, consequently, these will tend to accumulate over a period of years if a certain amount of drainage is not provided. There are many records of the use of water, relatively quite highly saline, in successful irrigation practice. The secret is the use of liberal quantities of the water, ensuring free drainage on open light-textured soils.

Should any deflocculation of the soil colloids occur as a result of the use of the water, the soil may be brought back to a satisfactory physical condition by treatment with such soil amendments as gypsum, flowers of sulphur, and lime. Gypsum is generally used at the rate of about a ton per acre, and sulphur at the rate of 200 to 500 pounds per acre.

The waters contain small amounts of fertilising ingredients, the most important of which are potassium and nitrogen as nitrate. The quantities which would be applied in irrigation practice are shown in Table 12.

TABLE 12.

QUANTITIES OF POTASH (K_2O) AND NITRATE NITROGEN APPLIED IN IRRIGATION WATER AT CARNARVON.

	Loc. 101.	Loc. 152.	Loc. 131.	Loc. 184.
Potash (K_2O)—	Well.	Bore.	Sands.	Pool.	Well.
Lbs. per 1,000 gallons	0·29	0·29	0·16	0·06	0·14
Lbs. per acre foot of water ...	78·5	78·5	42·5	16·4	39·2
Nitrate nitrogen—					
Lbs. per 1,000 gallons	0·0045	0·0045	0·0023	0·0023	0·0135
Lbs. per acre foot of water ...	1·23	1·23	0·61	0·61	3·68

Since the preparation of the manuscript a further sampling of the water being used for irrigation purposes has been made. The samples were examined for total water soluble salts, chloride, and reaction, with the results given in Table 13.

TABLE 13.

ANALYSIS OF IRRIGATION WATER USED FOR BANANA CULTURE AT CARNARVON SAMPLED BY THE TROPICAL ADVISER (MR. G. B. BARNETT), MAY, 1935.

Sample	II.	III.	IV.	V.	VI.
Location	101	152	131	184	396
Supply	Bore	Free river water	Free river water	Well	Well
Depth	64 feet	...	...	19 feet	...
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.
Total water soluble salts ...	46·9	48·9	51·4	28·6	84·0
Sodium Chloride (calc. from chloride)	29·8	26·8	26·3	11·0	45·4
Reaction, pH	7·6	6·9	7·1	6·6	7·3

Analyst—F. F. ALLSOP.

This sampling was from the same sites as in the previous one, except that Sample I. was not repeated, and an additional sample, Sample VI., was taken from a well on Location 396. The results are practically identical with the previous sampling, and show that there has been little seasonal change in the composition of the water in this instance.

The new sample, Sample VI., is higher than the others, and the figure, 84 grains per gallon of water soluble salts must be regarded as high for irrigation purposes, particularly under the climatic conditions prevailing at Carnarvon.

THE GROWTH OF PINEAPPLES AT CARNARVON.

An interesting situation presents itself in connection with the cultivation of pineapples on these slightly alkaline, calcareous soils of the Gascoyne. Pineapples are recognised as so-called calcifuges; that is, they appear to be adapted to acid soils and respond to physiologically acid manures such as sulphate of ammonia. The early results with pineapples at Carnarvon are promising, and it will be of interest to observe whether the soil conditions prevailing will have any deleterious effect after a period. It seems certain that liming these soils will be of no benefit, and may be harmful for pineapples, and that sulphate of ammonia should be used as the source of nitrogen where that element is included in the fertiliser mixture. Furthermore, sulphur may be a useful amendment for the promotion of the growth of pineapples on these soils.

SUMMARY AND CONCLUSIONS.

On the occasion of a visit to Carnarvon in August, 1934, the soils of the recent terrace of the Gascoyne River were investigated and samples obtained to represent the conditions in the area being developed for tropical agriculture.

These soils occur as a strip a few chains wide along both banks of the river between about three and 12 miles from its mouth, and have given very satisfactory results particularly with Cavendish bananas. Other tropical and semi-tropical fruits and crops are being grown with promising results.

The bed of the river lies in a channel from 12 to 30 feet below the level of the terrace and provides water supply and good drainage for the plantations.

The soils are immature and are represented by river sands of varying degrees of fineness. Three grades of deposits are described. On the basis of the texture three groups of soils were recognised.

Brown loamy sands and fine sandy loams constitute the most extensive and important group of soils. These soils are deep, permeable, and of good tilth and appear very satisfactory for agriculture under irrigation.

Thirty-seven samples of soil from 12 sites were examined for mechanical and chemical properties.

A feature of the mechanical composition of the soil is the general predominance of the fine sand fraction. In extreme cases the coarse sand amounts to as little as 1 to 2 per cent. of the fine sand fraction. Mica appears to be an important constituent mineral. Small amounts of calcium carbonate are generally present. On the basis of Hilgard's standards the soils are classed as poor to medium in nitrogen and organic matter, medium to normal with respect to phosphate, and good to rich in potash.

Citric acid extraction and the determination of replaceable potash indicate that the potash exhibits a high degree of availability.

The soils fall into the calcium group on the basis of the analysis of replaceable bases. Calcium averages 62 per cent. of the replaceable bases in the 12 samples examined. Magnesium and potash are relatively high in certain cases. Sodium is low, and averages only 5 per cent. of the total replaceable bases.

Total replaceable bases are relatively low, a fact associated with the immaturity of the soils, the light texture and the arid climate.

Five samples of irrigation water from wells, a bore and the river were examined and found to be fairly suitable for irrigation purposes. Dissolved solids ranged from 24 to 50 grains per gallon, with sodium chloride the principal constituent.

Literature reviewed.

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FACTORS INFLUENCING SEED GERMINATION.

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A farmer's seed purchase is frequently a considerable item and if, after incurring further expense due to planting operations, the germination is not satisfactory an appreciable loss is the outcome. Besides actual loss of labour and material, a germination failure often necessitates an unsown paddock during that particular season, associated with various direct and indirect inconveniences.

If this unfortunate circumstance of poor germination does arise, however, the reason is important in order to prevent its recurrence. In endeavouring to trace the cause many factors must be considered. There is a frequent tendency immediately to blame the seed, but on a number of occasions seed suspected of having a poor germinating figure has given, under test at this station, a high percentage germination.

The cause of failure to secure a good stand may have originated in the seed prior to sowing or may be due to the action of prevailing conditions after sowing. A normal seed is really a living embryo or germ along with a certain amount of stored food available to provide the necessary energy for the initial stages of growth. This embryo, which consists essentially of a rudimentary shoot and root capable of growth under favourable conditions, is comparatively easily damaged and killed.

MATURITY.

The maturity of seed when harvested has an appreciable effect on the germination. Small and shrivelled seeds do not usually produce normal seedlings capable of giving rise to healthy plants, and their germinating vigour is also low. Some seeds require a resting or maturing period after they have actually been harvested. This is forcibly demonstrated in the case of Paspalum (*Paspalum dilitatum*), which, unless treated, usually requires a month or more maturing period after gathering before a ready germination can be secured. If Paspalum seed is soaked for about twenty-four hours at approximately room temperature the speed of germination is materially increased although there is no significant increase in total germination.

SOUNDNESS.

During harvesting and cleaning processes, a percentage of most seeds becomes broken, cracked and chipped through contact with, particularly, the metal parts of the machinery. This is most evident in the cases of comparatively large, brittle seeded legumes such as subterranean clover and burr trefoil. Some of these broken seeds are eliminated during winnowing and grading processes, but an inferior line may contain an appreciable quantity. If the actual embryo of a seed has been damaged, it will produce at best a malformed or broken seedling, which will be unable to compete with its normal neighbours. A seed slightly chipped, distant from the embryo, will usually produce a normal seedling but when, say, one third of the seed is broken away the resultant growth is of a doubtful nature. Any crack in the seed coat, however, whether visible or not discernible to the naked eye, increases the risk of fungal infection, and the presence of fungous growths in seeds causes a rapid decrease in germinating capacity.

VIABILITY.

The ability of various seeds to retain their power of germination shows enormous variation, and even the limit for one individual species will vary according to the nature of growth and conditions of harvesting and storing. A common misconception is that seeds will live indefinitely but, of course, this is *far* from being the case. Myths of this nature are given support by the supposed germination of "Mummy" wheat secured from Egyptian tombs upwards of 2,000 years old. Many tourists are willing to pay for "Mummy" wheat and not much initiative is required by local residents to place grains of wheat in the mummy cases and replenish the supplies when necessary. Actual experiments have proved that only 8 per cent. of wheat grains stored under ideal conditions for sixteen years sprouted at the end of that time, and by the time the seed was 35 years old, no germination at all could be induced. Wheat and other seeds frequently have been found in old Egyptian tombs, but microscopic examination of such grain invariably shows that the embryo has acquired a brownish colour and is practically destroyed.

The following table taken from the International Review of the Science and Practice of Agriculture, April-June, 1924, by K. Dorph-Petersen, gives an excellent idea of the period for which certain agricultural seeds will retain their viability:—

Percentage Germination each year.

Age of Seed.	White Clover.*	Alsike Clover.*	Lucerne.*	Trefoil.*	Red Clover.*	Bent Grass.	Italian Rye Grass.	Cocksfoot Grass.	Kentucky Blue Grass.	Yorkshire Fog Grass.	Perennial Rye Grass.	Timothy Grass.	Meadow Foxtail Grass.	False Oat Grass.	Rough-stalked Meadow Grass.	Meadow Fescue Grass.	Reed Canary Grass.
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1 year ...	98	99	99	99	100	91	83	90	78	86	92	98	89	98	98	98	49
2 years ...	99	99	95	99	100	96	79	85	94	87	89	95	84	94	98	94	29
3 years ...	90	98	96	94	100	93	79	88	87	84	89	91	66	88	95	96	20
4 years ...	91	96	87	87	91	92	65	88	85	76	87	79	56	83	94	81	2
5 years ...	87	70	82	73	52	92	57	77	72	57	67	53	30	50	78	42	—
6 years ...	61	33	68	43	10	91	40	71	44	42	41	12	10	16	40	66	—
7 years ...	31	23	63	26	4	80	22	59	32	31	24	4	4	6	9	—	—
8 years ...	26	19	55	15	2	50	15	27	12	14	10	1	1	—	—	—	—
9 years ...	21	20	42	11	1	44	6	16	10	1	3	—	—	—	—	—	—
10 years ...	18	15	38	5	3	32	2	1	1	1	—	—	—	—	—	—	—
11 years ...	14	17	18	5	1	17	—	—	—	—	—	—	—	—	—	—	—
12 years ...	13	19	12	6	4	4	—	—	—	—	—	—	—	—	—	—	—
13 years ...	10	16	12	4	3	1	—	—	—	—	—	—	—	—	—	—	—
14 years ...	10	15	7	2	—	—	—	—	—	—	—	—	—	—	—	—	—
15 years ...	8	13	4	2	—	—	—	—	—	—	—	—	—	—	—	—	—

* Including viable "hard" seed.

These figures, which originated from the Danish Seed Testing Station, were derived from seeds stored at about 18deg. C. in a dry atmosphere and definitely establish the relationship of germination and age.

PICKLING AND DISINFECTION.

Under certain circumstances, pickling and disinfecting with chemicals decrease the germination, especially if the seeds are fractured in the vicinity of the embryo. Dry pickling wheat for smut with copper carbonate is less liable to damage the grain than wet pickling with blue-stone (copper sulphate). Experiments carried out by this department have shown that onion seed treated with a .1 per cent. solution of corrosive sublimate for thirty minutes is not affected in germination if thoroughly washed with rain water and then dried. Tobacco seed treated with

alcohol for downy mildew (blue mould) if thoroughly dried at little above room temperature shows no decrease in germination. If these disinfection processes are not carried out with reasonable care, however, considerable decrease in germination may be experienced. If the seeds are not thoroughly dried, many will lose their vitality and, in the case of tobacco, if the seed is heated to a temperature much in excess of 40deg. C. (104deg. F.) an appreciable falling off in germination will result.

STORAGE AND TRANSPORT.

Conditions during seed storage and transport are frequently the cause of lowering the percentage capable of germinating. A cool, dry atmosphere remaining at a comparatively constant temperature constitutes favourable conditions. Dampness causes heating followed by mould growths, which, in the presence of warmth and moisture, soon permeate a large stack. If seed becomes damp, it should immediately be spread in a thin layer on a drying floor and turned over frequently until completely dry. Immediate action in this respect saved several hundred pounds worth of subterranean clover seed, which was wet by rain during transport to Perth some short time ago.

Weevils and other insects are also sources of trouble when storing seed. If any trace of live, destructive insects is evident the seed should be thoroughly fumigated with carbon bisulphide or some other suitable substance.

HARD SEED CONTENT.

The immediate germination of some leguminous crop plants is frequently affected by the so-called "hard seed" content. These seeds have coats which are impermeable to water and will remain so for varying periods up to a number of years. While this is the case, they will not swell and germinate. Once an annual clover is established the presence of "hard seeds" to a reasonable extent is of value for ensuring a stand each year. Early rains followed by a dry period may germinate the ordinary seeds produced by the seeding down of the previous year's crop, only to kill most of the young seedlings. Under such circumstances, the hard seeds, the germination of which has been retarded, form seedlings at a more seasonal period, and thus produce entirely or increase considerably the stand of the clover. At the time of original planting, however, when the actual date of sowing can be regulated to suit the conditions prevailing that season, the presence of a large percentage of hard seeds must be considered detrimental. Drooping flowered clover (*Trifolium cernuum*) seed produced in this State probably has the highest average "hard seed" content of any clover species in the world.

Frequently, this is as high as 99 per cent., and during recent years has rarely been below 90 per cent. Fortunately, by means of a scarifying process, this figure can be reduced to 40 per cent. or even less, thus giving an immediate germination in the vicinity of 50 per cent.

TIME OF SOWING.

A good germinating line of seed sown under unfavourable conditions will give a poor stand. If a sowing is made with the early autumn rains, and then a dry period is experienced, the young and delicate seedlings may be completely destroyed. Thus the stand will depend on any further germination at the commencement of the regular rains. Again, if spring sowings of such crops as maize are made too early, before the soil is sufficiently warm, the seeds will decay and necessitate replanting. The optimum germination temperatures for different plants vary considerably, as exampled by the ranges for oats and maize, which are 77deg to 80deg. F. and 99deg. to 111deg. F. respectively.

SEED BED.

The nature of the seed bed in another important factor influencing the resultant germination. Especially when sowing small seeds the soil should be worked into a fine tilth with the elimination of all large clods. The fine soil should then be consolidated and a loose shallow surface layer prepared. By this means, when the seed is sown it rests upon a firm bed and is covered by fine soil, thus allowing ready access of two essentials, air and moisture. This system is regarded as essential when raising garden seedlings, but is no less so when originating expensive permanent pastures, particularly when the seeds are small.

DEPTH OF SOWING.

Many cases of poor stands have been caused by sowing too deeply. Small seeds with their necessarily limited amount of stored energy cannot penetrate several inches of soil, as no further energy is available until the shoot reaches light. For general purposes, to arrive at a satisfactory depth for planting seed should be covered with twice its own thickness of soil, and when sowing a mixture the smallest seed is the limiting factor of the depth.

MIXING WITH FERTILISERS.

A practice frequently carried out is the mixing of small seeds with superphosphate prior to sowing. In some cases very unsatisfactory germination has resulted, evidently due to the action of mono-calcic phosphate on the seeds. Investigations indicate that the sowing of small seeds along with superphosphate if conducted with certain precautions will give a normal germination. The superphosphate should be the driest obtainable and drilling should be completed as soon as possible after the seed has been mixed with the fertiliser. The soil, at the time of sowing, should be thoroughly moist and in a favourable condition to promote germination.

AGRICULTURAL PROBLEMS

Agriculturists, pastoralists and primary producers generally, who may be having difficulties of any kind in connection with their production activities, are invited to communicate with the Agricultural Adviser of their district of the Department of Agriculture, when information and advice will be supplied free of charge.

Where identification of plant or stock diseases or insect pests is required, full details of symptoms should be forwarded and also samples of the diseased plant, animal tissue or insect where practicable. Plant tissue intended for examination by the Plant Pathologist should be wrapped in paper and not forwarded in airtight containers, and plant specimens for the Botanist should be pressed between newspaper and dried before despatch. With regard to animal tissue for microscopic examination, this should be forwarded in a solution of 10 per cent. formalin, or if of considerable bulk in a sealed kerosene tin containing a few ounces of formalin as a preservative. Living insects should be sent in suitable containers and dead specimens in methylated spirits.

The addresses and names of Advisers are as follows:—Albany, A. C. Vaughan; Bridgetown, A. Flintoff; Bunbury, M. Cullity; Denmark, V. Cardon; Geraldton, G. L. Throssell, Government Buildings; Gosnells, R. C. Owen; Harvey, D. L. Breen (Fruit) and C. Giles (Dairying); Katanning, A. S. Wild; Manjimup, J. Ireland; Mundaring, V. Cahill; Northam, F. L. Shier; Northcliffe, A. Sharp; Vasse, J. M. Nelson.

DESCRIPTIVE ACCOUNT OF THE CODLIN MOTH, TOGETHER WITH NOTES ON ITS CONTROL.

CODLIN MOTH.

(*Cydia Pomonella.*)

L. J. NEWMAN, F.R.E.S., Government Entomologist.

Although an insect of European origin, the Codlin Moth has spread and established itself in almost every country of the world in which the culture of pip fruit (apples, pears, quinces, etc.) ranks as an industry having any claim to importance.

Its destructive ravages, entailing great annual losses, have become a veritable by-word to the orchardist, and he naturally regards, with feelings of genuine alarm and dismay, the possible invasion of his crop.

It may emphatically be asserted that many fruitgrowers' prospects have been completely ruined by its ravages, and in spite of the introduction and use of combative measures, it still levies a heavy yearly toll upon the grower of apples, pears, and quinces in all the Australian States, with one notable exception, namely, Western Australia. Probably in no country of the world has the trial of various preventive measures been more assiduously essayed or this insect pest been more penetratively studied than in the United States of America. Be this as it may the Codlin Moth, according to reputable American authorities, possesses the reputation of causing greater financial loss in the pome fruit-growing industry than the totality of other known pome fruit insect pests in existence in that country (Fruit Fly is non-existent in U.S.A.), and where the application of modern combative measures is neglected, this loss it is stated may be anything from 25 per cent. to 75 per cent. of the total crop.

Some 69 years have elapsed since the first appearance of this formidable pest in Australian orchards was first noted and recorded.

The absence of this undesirable insect in the apple-growing districts of Western Australia is a matter of extreme importance. Any fruitgrower who has had experience of the difficulties of keeping this pest in check is fully seized of this fact. In Western Australia apple-growing possesses great future possibilities and potentialities. The industry is soundly established and capable of great and progressive extension. Freedom of his orchard from this pest gives the local grower a distinct advantage over his Eastern competitors.

While this pest is non-existent in this State, and every effort has been and is being made to prevent its introduction, it behoves the West Australian orchardists to be continually on the alert, in order to detect the possible presence of the pest.

The object in compiling this Bulletin, which includes a descriptive plate drawn from local-bred specimens, is to make the grower as familiar as possible with the more general characteristics of the insect, so as to facilitate its identification, and to impress upon him the urgent necessity of submitting any insect suspected of being this undesirable pest to the Entomologist of the Department of Agriculture, for prompt identification. To check the dissemination of this and other insect pests, the first line of action is the application of prompt and correct measures for its isolation and eradication, and to accomplish this end the Department of Agriculture relies on the active co-operation of the grower.

DESCRIPTION OF INSECT.

Dimensions of Moth. -The Codlin Moth is a comparatively small insect measuring about ⅝ inch in body length, and having, when its wings are fully extended, a breadth measurement from wing tip to wing tip of about ¾ inch. These measurements, it may be noted, represent the average derived from a series of actual measurements made on twelve insects collected during the localised outbreak of 1910 in the Perth-Metropolitan area.

The colouring of the front or anterior pair of wings is, as will be seen from the accompanying plate, a mixture of grey and brown, the latter colour predominating in the form of more or less dense irregular transverse markings over a background of dull grey. Towards the end of each forewing is a darker oval patch on which are three golden marks. These latter need closer examination to discover. The patches and the golden marks are the main distinctive identifying characteristics of the Codlin Moth. The hind or posterior wings are of a uniform light brown colour, and are also bordered by a fringe of fine hairs. These wing markings are more readily made out with the aid of a hand lens.

The head and thorax are slightly more heavily coloured than the forewings, and the body segments are a trifle darker than the hind wings. (See Plate I.)

The Codlin Moth customarily emerges from its habitat at dusk or on exceptionally dull days, and is therefore very seldom seen during daylight. It is a strong flyer and will travel long distances when forced to.

Conditions which favour the first appearance of the Moth.—Under normal seasonal conditions the first brood of moths make their appearance after the middle of September and during October; that is in the early spring, when the apple and pear trees are in blossom. This first brood originates from the larvae or caterpillars which entered into winter quarters the previous autumn. Within a day or two after emergence from the cocoon, the mating of the male and female moths ensues and is almost immediately followed by egg-laying. The life of the moth is normally 20 to 25 days, and during this period the female moth lays from 80 to 100 eggs, each of which is whitish in colour, scale-like in shape, and roughly approximates in size a pin's head.

In about eight to ten days a caterpillar or larva is hatched from each fertile egg. The head of the caterpillar is dark, the rest of its body almost transparent and measures about 1/16th inch in length. Natural instinct appears to direct the movements of the young larva or caterpillar to the calyx of the fruit where the skin is least tough. Arrived here it remains for three or four days eating in the calyx before penetrating to the seed or pip cavities of the fruit, where it subsists for three or four weeks. The almost fully grown caterpillar or larva then usually makes its way to the surface of the fruit, not however by the way in which it enters, but by eating a lateral or side tunnel through the fleshy portion of the fruit. The excreta discharged whilst boring is intermingled with a silky webbing spun by the caterpillar. This is usually observable protruding from the eye of the apple. Having tunnelled its way to the surface of the fruit the larva emerges when ready to spin and pupate.

Adult Caterpillar.—The adult or fully grown caterpillar (larva) is a stout object ⅛ inch in body thickness, slightly under ¾ inch long, flesh-coloured, and having a few stiff hairs scattered over its body, which consists of 13 well-defined segments, or body divisions. Attached to each of the first three segments is a pair

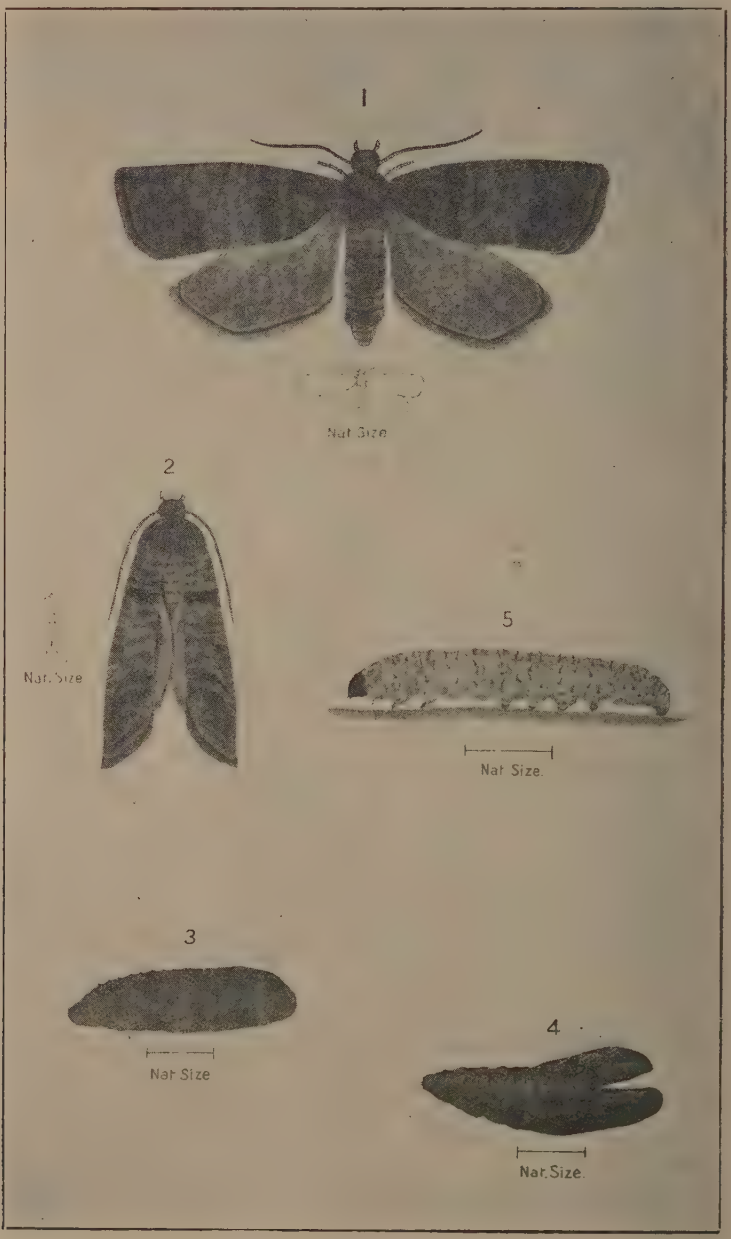


PLATE I.

The Codlin Moth (*Cydia pomonella*).

Fig. 1.—Moth on wing. (Multiplied 4 times.)
Fig. 2.—Moth at rest. (Multiplied 4 times.)
Fig. 3.—Pupa. (Multiplied 3½ times.)
Fig. 4.—Pupa case, after moth has emerged.
Fig. 5.—Adult larva or caterpillar. (Multiplied 3½ times.)

(Original.)

of legs. On the 6th, 7th, 8th, 9th, and anal or last segment these appendages or legs are apparently reduced to so-called sucker or false feet. The other segments are legless. (See Plate I.)

As a rule 10 small dots or markings may, with the aid of a hand lens, be made out on each of the body segments. These are not constantly visible, all specimens not exhibiting this feature. The adult caterpillar descends from the infested fruit (frequently affected fruit falls prematurely) either by means of a silken thread which it spins or by crawling down the tree trunk. Once on the gound it secretes itself under an earth clod, in the crevices of boxes, old fences, or bagging, but apparently by preference, under more or less sheltering crevices or chinks, afforded by the tree trunk. Here occurs the transformation of the caterpillar into the pupa. (See Plate I.)

Pupa.—This is a reddish brown object ½in. long, enveloped in a white flimsy silken cocoon from which, after a period of about 20 days, the moth emerges as a representative of brood No. 2.

Second-brood Moth.—These second-brood moths emerge from the above described pupæ, during December to the first week of January.

Egg-laying, as with the earlier brood, shortly eventuates, but the resultant young caterpillars do not always enter the fruit through the blossom end. Frequently they gain entrance at a point where two fruits or a leaf and fruit are in contact. Many pip fruits by this time are half-grown, and in the case of early varieties nearing full growth. Any patches of a brown dust-like deposit upon the smooth surface of the fruit should be very carefully examined for possible points of entrance of larvæ. The caterpillars when fully fed emerge from the fruit, hide themselves, and just as in the case of the first brood, spin and envelop themselves in a cocoon, in which they pupate. This completes the life cycle of second brood.

The writer's observations lead him to advance the view that a third brood, limited in numbers it is true, emerges towards the end of March, for in the course of an experiment, four third brood moths emerged between the 20th and the 24th of March in the observation cage.

It is fortunate from the grower's point of view that this pest has never been given a fair and full opportunity to establish itself in this State, and consequently a conclusive demonstration of the occurrence of this suggested third brood, under field conditions, remains an open question. On account of the lengthy duration of our summer, the view advanced has valid claims to probability.

The last brood of caterpillars spin a slightly stouter cocoon than their forerunners, evidently to meet the necessity for protection against the cold and dampness produced by our normal winter conditions. The caterpillars do not, however, at once change into pupæ, but remain in the caterpillar stage within their cocoons during the autumn and winter. The advent of spring induces the transformation into the pupa stage, which is quickly followed by the emergence of moths during September or October. Egg-laying then commences, and the life cycle already detailed once more begins.

The writer noted, during an outbreak in the metropolitan area of Perth, two features which are probably novel. Firstly, the discovery of several larvæ, subsisting within the buds of terminal shoots of apple trees. Secondly, the spinning of two cocoons by a single larva. The first cocoon was spun during the autumn in corner of breeding cage within which the larva hibernated during the winter. Before pupating in the early spring the larva spun a second cocoon which protruded from the first (see Plate II.), and in this it pupated and finally emerged as a moth.

Feeding habits.—It its desirable to especially direct attention to the fact that the Codlin Moth is an insect which, in its larval stage, feeds inside the fruit which it infests; it cannot therefore be very well confused with insects which feed for the most part on leaves, buds, bark, etc. It is not uncommon to meet with instances

PLATE II. (Original.)

New Cocoon.

Old Cocoon.

where some confusion has arisen on the part of the orchardist in regard to the discrimination between the larvæ of the Codlin Moth and the Fruit Fly. It may be opportune, therefore, at this juncture to state certain of the more readily recognisable points of difference presented by these two fruit pests.

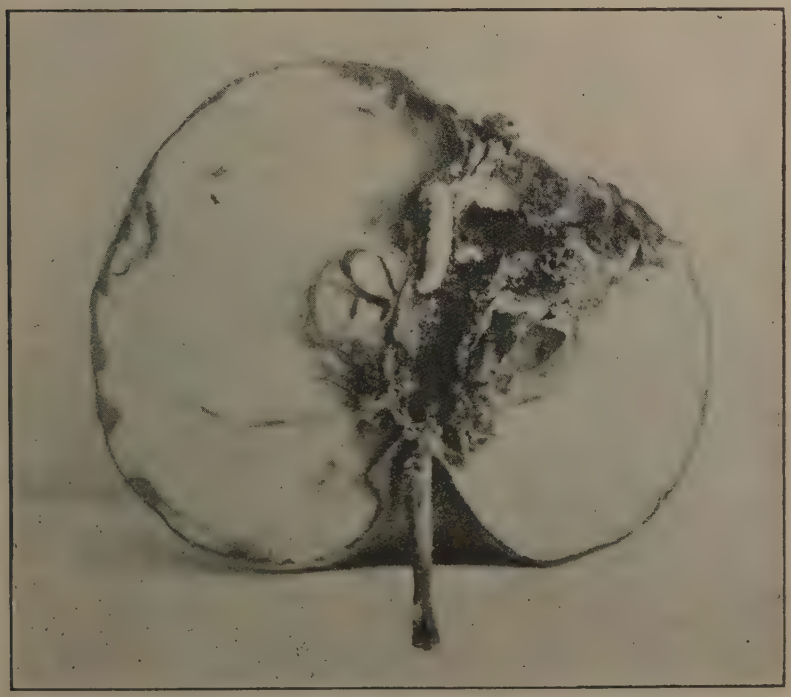
The *Fruit Fly,* with her ovipositor, makes a small hole in the fruit in which she lays a number of eggs (usually from eight to ten), and as a consequence a number of maggots (larvæ) are to be found in the tissue of the fruit at each point of attack. This quickly causes the fruit to decay and fall. The *Codlin Moth* lays her eggs on the surface, the resultant larvæ burrowing their way into the fruit; rarely is there more than one caterpillar in each fruit infested. Externally the infested fruit often presents an apparently sound appearance and frequently close observation alone will enable one to decide whether or not the larva is inside. As a general rule the excreta of the caterpillar either blocks the point of entrance or on the external surface of the fruit is to be found evidence of its possible existence in the interior of the fruit.

The larva of the Codlin Moth is a caterpillar with six legs attached to the first three anterior segments and 10 false legs (or sucker feet) attached to the 6th, 7th, 8th, 9th and posterior segment of the divisions.

The larva of the Fruit Fly is a maggot, devoid of legs, with small tapering head and blunt ended body. Placed upon a dry surface it is able to spring to a considerable distance.

The two larvae differ in size. The fully fed moth caterpillar is nearly ¾in. long, the maggot of the Fruit Fly never exceeds ½in. in length.

PLATE III.



Cut apple showing typical work of caterpillar. Note pips have been consumed.
(Original.)

DISSEMINATION OF THE MOTH.

(1) Use of second-hand fruit cases in which moth-infected fruit has been packed. During transit many of the caterpillars emerge from the fruit and enter cracks or crevices in the case, and there spin their cocoon. Examination of such cases forming part of consignments of condemned fruit has revealed the fact that moth caterpillars had embedded themselves in the soft wood of the packages.

(2) The sale of fruit infested with the larva of the moth.

(3) Passengers' luggage is a vehicle of introduction; travellers from the Eastern States, probably unconscious of the regulations preventing the introduction of pip fruits into the State, occasionally bring them in their personal luggage. Several instances are on record where such packages, upon examination, were found to contain 50 per cent. of infested fruit.

(4) The importation of pip fruits from countries known to be infested with Codlin Moth has proved to be a means of introduction in spite of all possible precautions taken.

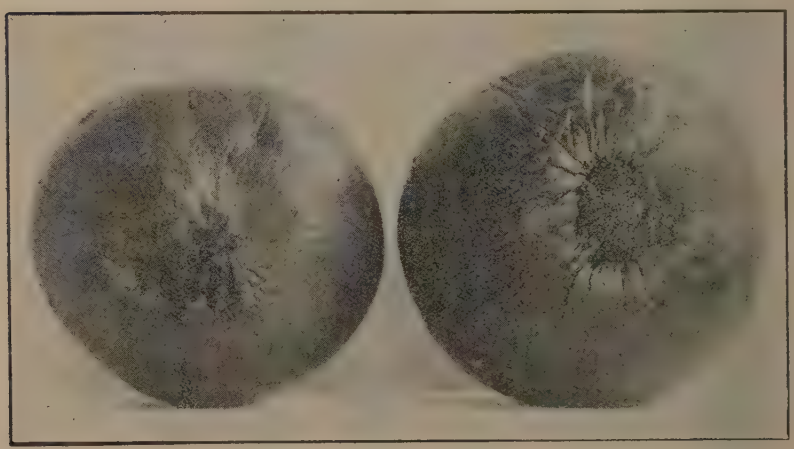
RECOGNITION OF MOTH-INFESTED FRUIT.

The chief characteristics of moth-infested fruit are:—

(1) A collection of castings more or less held together by webbing in the calyx of the fruit which, when removed, reveals a tunnel descending into the core.

(2) The fruit, when the larva has established itself well within, generally exudes a brown gummy substance from the mouth of the entrance tunnel. The escape hole seldom exudes this gummy matter, the larva pushing it back into the cavity made in the centre of the fruit. The presence of this substance is almost infallible evidence that the larva is within.

PLATE IV.



Apples showing typical castings of Codlin larvae.

(Original.)

(3) Affected fruit usually turns yellow in the eye or other point of attack, and ripens and falls prematurely.

(4) The exit hole of the caterpillar.

SUMMARY.

1. Codlin Moth attacks apples, pears, quinces, and all other pip fruits.
2. In very severe outbreaks other fruits are sometimes found attacked.
3. Two broods of Codlin Moth make their appearance during the year.
4. The first brood of Moths appears with the blooming of the trees.
5. The larvae of the first-brood moths generally enter the fruit at the calyx end ; those of the second and probably third broods, at many other points than the calyx, such as where two or more fruits are clustered together, or a leaf is lying against a fruit.
6. Number of eggs laid, 80 to 100.
7. Egg period, 8 to 10 days.
8. Larval or caterpillar stage in fruit, 20 to 25 days.
9. Pupal stage during summer, 18 to 20 days.
10. Life of Moth, 20 to 25 days.
11. The last batch of caterpillars in the Autumn do not at once pupate, but remain in the larval stage within the cocoon, transforming into the pupa 14 to 16 days before emerging in the Spring.
12. The Codlin Moth larva is a caterpillar half to five-eighths of an inch long of a fleshy pink colour, and feeds inside the fruit.
13. It is easily recognised from the larva of the Fruit Fly.
14. The larva of the Fruit Fly is a maggot three-eighths to half an inch long, varying in colour, according to the food supply, but usually of an opaque, creamy yellow ; with a small tapering head and blunt ended body.
15. Infested fruit can be easily recognised by the castings of the larvae entangled in a silky web ; a brownish, gummy substance oozing from the point of entry ; premature ripening and falling.
16. When the larva has made its exit, a noticeable hole is seen in the fruit.

PREVENTIVE AND COMBATIVE MEANS.

Up to this point we have dealt only with the characteristics and habits of the Codlin Moth, a knowledge of which should prove helpful in appreciating measures for the control of the pest.

We now detail certain remedies which have been used successfully both here and elsewhere, but might here state that once the pest obtains a firm footing in any pip fruit growing centres it is impossible to absolutely eradicate it, and the expense of keeping it in check is a heavy item. The saving to this State by the absence of this one pest cannot be estimated.

Fortunately it can be kept under control by artificial measures, such as scraping of trunks and main branches, probing all cracks, crevices, and decayed places on the trees, whitewashing the trunks, bandaging, orchard sanitation, and spraying.

1. Scrape the tree trunks and larger branches to remove any loose and old bark, thus removing all natural shelter.

2. Carefully probe and scrape all cracks, crevices, and decayed places on the trees.

3. Whitewash the trunks with lime to keep the growth of moss and lichens down, which otherwise would afford suitable attractive places for the larva to spin under.

4. *Bandaging.* The object of this is to provide an enticing spinning place for the larva.

First scrape the trunk and main branches free of loose bark, then bandage the tree with a strip of clean coarse bagging from 6in. to 8in. wide, sufficiently long to meet around the trunk. Place about 6in. to 8in. from the ground. Tie bandage tightly round the centre with a piece of stout binder twine. Pull the upper portion of bandage down over the lower, leaving a space between the two into which the larva will crawl and spin. The bands should be placed around the tree trunks not later than the 1st November.

PLATE V.

Method of tree bandaging for trapping the Codlin caterpillar. (Original.)

Regularly examine at intervals of eight to ten days and destroy all larvæ from beneath with a knife, or dip the bandage into boiling water for at least five minutes. The better plan by far is to destroy the larvæ or pupæ with a knife. When removing the bandage, see that any caterpillar or grub which falls to the ground is destroyed; the cocoon is often fastened to both the trunk and the bandage. The danger of removing the bandages for dipping in boiling water is that many larvae and pupae may be dropped and escape, nullifying a great part of the work. Placing a bandage around the trunk and then neglecting to look at it again is worse than no bandage at all, it being simply a breeding ground for the moth.

Any stakes or props used to support the over-weighted branches should also be bandaged, otherwise many of the larvæ will crawl up these into the heads of the trees and there spin and pupate. Bands are of little use if there are other places left where the caterpillars can hide.

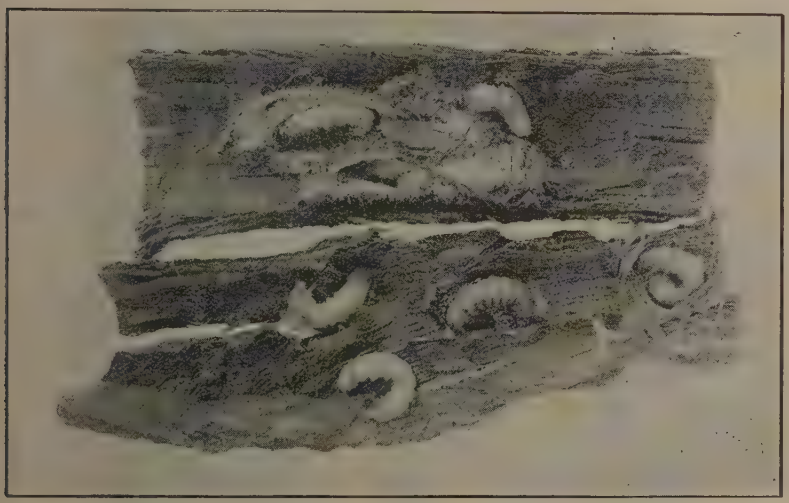
5. Destroy daily all infested fruit both on trees and ground, by boiling or burning. This is essential in the control of the pest.

6. *Orchard sanitation.*—Keep the orchard free of weeds and rubbish and well cultivated during the Spring and Summer months. Thoroughly clean all packing and store houses. Caterpillars in fruit that may have been brought in from the orchard and stored therein will, when mature, leave the fruit, crawl into any

crevice, corner, or rubbish and there spin and pupate. In due course the moths will issue and escape from the packing house to the orchard. Therefore, every packing house and storeroom should be fitted with spring-hinged wire doors and the windows covered with gauzing, thus preventing the escape of the moth. The moths will fly to the windows and may there be destroyed. Any other possible means of escape should be stopped.

7. Avoid the use of second-hand fruit cases, packages, or bags. These have been proved to be the greatest medium in the spread of the pest. Fruitgrowers will therefore find it to their advantage not to allow any second-hand case, package, or bag on their premises unless it has been previously thoroughly immersed for five minutes in boiling water and soda.

PLATE VI.



Hibernating larvae of Codlin Moth taken under bark during month of May.
(Original.)

8. Never allow, under any circumstances, the forwarding of infested fruits into clean districts. Fruit may be sent hundreds of miles from where it was grown and a fresh centre of infestation started.

9. Submerge all utensils used in the picking or storage of fruit in boiling water and soda for five minutes.

10. Examine the trunks of the trees and also below the soil, as it has been found that the Codlin larvæ sometimes find suitable lodgment there. In orchards that have not been kept well worked the soil cracks at the base of the trees and entices the caterpillars to spin there.

11. Avoid dense clusters of fruit, as where two or more fruits touch is a favourite point of entrance for the second brood larvæ and is a place very difficult to reach with the spray.

11A. *Luring.*—It has been proved that the Codlin Moth is susceptible to the odour given off by the following mixture: 10 parts of vinegar to 90 parts of water. This lure is placed in open-mouthed glass jars of about one pint capacity and three-

quarters filled with the liquid. These jars are then suspended in the upper portions of the trees at various distances throughout the orchard. It is not economically possible to place these jars in every tree, but as many as can be economically worked should be used. The moths are attracted, and are drowned in the liquid. The use of the lure is twofold, in that not only are egg-laden females captured, but it enables the grower to determine the period when the moths are most active in large numbers, which in turn acts as a guide when to spray.

12. *Spraying.*—No matter how carefully the measures mentioned are carried out they will prove of little value without spraying. Spraying alone will give good results; but the best results are naturally to be expected where spraying is practised in conjunction with the other measures mentioned. The initial expense involved in the purchase of a suitable spraying outfit deters many orchardists from obtaining same, but gradually they will realise that profitable fruit-growing cannot be carried on without the necessary appliances. The gain in clean marketable fruit will more than repay the cost.

PLATE VII.

The above plate was made from a photograph of a flowering specimen of the apple taken immediately after the fall of the petals. The small green lobes which persist after the petals have fallen and are to be seen at the apex of each young fruit, collectively constitute the calyx of the flower. When in this condition the first spray should be applied, as later on the calyx closes over and the young eye of the fruit becomes inaccessible to the spray. (Original.)

When to spray is the most important point to know. In order to get the best results from the first spraying it is necessary to do it at the right time. Plate VII. shows the blossoms at the right period for the first spraying. This is just as the petals fall and before the calyx closes. If delayed until the calyx closes, the chief object of spraying at this time, which is to place the poison well down in the calyx, is defeated.

If spraying is done too soon most of the poison will settle on the parts of the flower that are not persistent, and when these parts fall off the poison will be lost.

The reason for placing the poison particularly in the calyx in the first spraying is that the natural instinct of the young larvae or caterpillars appears

to direct their movement to the calyx of the fruit where they feed before entering to the seed or pip cavities. If this food is well covered with the poison the tiny larvae will be destroyed before they enter the fruit. To thoroughly accomplish this it is necessary to use a coarse nozzle with full pump pressure, and the spray driven straight at each calyx. For all sprayings other than when applying the poison to the calyx, use a fine nozzle and cover the fruit well with the fine spray. Knowing that the moths continue to emerge for at least three weeks and that many trees are irregular in their flowering, it becomes necessary to apply a second and third spraying.

The second spray should be applied ten to twelve days after the first. The third spraying should follow the second 14 days later. These three sprayings, if applied at the right time, and carefully done, should ensure the death of at least 90 per cent. of the first brood larvae.

Unfortunately, in dealing with the control of any pest, we have always to reckon with the careless and indifferent orchardist, whose orchard is often nothing more than a breeding ground for the pest. Ther are also many orchards and old trees that have been abandoned, nobody appearing to claim the fruit therefrom; these are also a general breeding ground.

Due to the possibility of having missed some of the first brood larvae, which will eventually become second brood moths, together with the reinfestation by second brood moths from outside sources, such as those mentioned, it will be be necessary to apply a fourth spray six weeks after the third, followed by a fifth 10 to 12 days after the fourth, and a sixth spray 14 days after the fifth. In spraying for the second brood it is necessary to fill the eye of the fruit as well as carefully covering the whole outside, as many of the second brood larvae frequently enter at the eye.

The spray needs to be carefully forced between two or more fruits which are touching, as this is a common point of entry for the tiny larvae. This second series of spraying should be sufficient to control the second brood. Should there be a third brood, which would be probable if once established in this State, owing to our protracted summer, it will be necessary to again spray three times in March-April at similar intervals.

WHAT TO SPRAY WITH.

Arsenate of Lead.—This is the spray now universally used against the Codlin Moth caterpillar. It is simple to mix and safe to use. When once dry on the fruit or foliage it is not readily washed off by rain.

The formula recommended by the Department is Arsenate of Lead, 1½ lbs. of powdered form to 50 gallons of water. There are several good brands of this poison on the market.

SPRAY SPREADER.

Calcium casenate.—Owing to the tendency of the above mixture to run into globules it is considered advisable to add what is termed a spreader. Some brands of Arsenate of Lead have this incorporated, and thus do not need any addition when being applied. These spreading preparations have been prepared by various firms. They are generally used at the rate of 1 lb. of spreader to 100 gallons of the Arsenate of Lead mixture. It is best to take 1 lb. of spreader to 1 pint of water, stirring rapidly. This will form a paste; add more water and stir thoroughly for two or three minutes, then pour into tank, adding the other ingredients afterwards.

The Arsenate of Lead is also made into a thin milk-like consistency before being placed in tank.

When both ingredients have been so reduced add the necessary amount of water to bring to the required strength, and thoroughly mix. Keep well agitated when using.

Pumps.—A pump with a good agitator should be used. If a power pump is not used—and this is the best—the man doing the pumping must maintain a high and constant pressure to do good work. A pressure of at least 70 to 90 pounds to the square inch is necessary to produce a good spray. The all-important thing is to apply the spray at the right time, and so thoroughly that no blosom, fruit, or foliage is left uncoated with poison.

If the above-mentioned preventive and combative measures be correctly applied the losses by this pest can be reduced 98 per cent. Where neglect occurs the losses may be anything from 25 to 75 per cent. of the crop. Prevention is better than cure, and, as is stated in the introductory pages of this Bulletin, it behoves every grower who discovers any insect pest of which he is suspicious or in doubt to forward same to this Department for identification. Earliest possible identification and prompt measures are essention to combat the outbreak of any insect pest. Do not suppress the fact that a pest has obtained a footing in your orchard, as the Department is only too anxious and willing to assist in the eradication or control of any pest whatever its nature may be. Once an insect obtains a strong footing in a district it is generally there for all time.

As an instance of what can be done by the prompt recognition of a pest and the application of combative measures, I only need to quote the outbreaks of Codlin Moth which have occurred in the State, and which have been successfully eradicated by the Department before the infested area became too large. Any neglect in these instances would have resulted in the permanent establishment of the Codlin Moth in the State.

SUMMARY.

1. Scrape loose bark from trunks and branches ; clean out all cracks and crevices, and destroy all caterpillars found.

2. Whitewash trunks with lime.

3. Bandage trunks with hessian traps as described.

4. Destroy daily by boiling all infested fruits, both on trees and ground.

5. Keep orchard well cultivated and free of rubbish and weeds.

6. Thoroughly clean all packing sheds and store rooms.

7. Fit packing houses with spring-hinged wire doors, and cover windows with gauzing.

8. Stop up every other means of escape.

9. Avoid the use of second-hand cases, packages, or bags, unless previously immersed in boiling water and soda for at least five minutes.

10. Prohibit the carriage of infected fruits into clean districts.

11. Submerge in boiling water for five minutes all utensils.

12. Examine tree trunks below the ground for pupae and larvae.

13. Thin out fruit to prevent clusters.

14. Apply first spray just as the petals fall and before the calyx closes, using a coarse nozzle and high pressure.

15. Apply second spray with fine nozzle 10 to 12 days after the first.

16. Third spray follows the second 14 days later.

17. Fourth spray six weeks after the third.

18. Fifth spray 10 to 12 days after the fourth.

19. Sixth spray 14 days after the fifth.

20. Should there be a third brood, it will be necessary to spray again in March.

21. Strength of Arsenate of Lead—1½ lbs. to 50 gallons water.

22. Use pump with a good agitator, maintained at a pressure of at least 70 to 90 pounds per square inch.

23. See that the spray is applied at the right time, and so thoroughly that no blooms, fruit, or foliage are left uncoated with the poison.

24. Prompt identification and application of combative measures, together with the co-operation of all growers, is essential in the eradication or control of any insect pest.

TOXIC PARALYSIS (BOTULISM) OF SHEEP IN WESTERN AUSTRALIA.

FEEDING EXPERIMENTS AT MECKERING AND BEVERLEY.

By

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and

F. L. SHIER, Senior Agricultural Adviser.

Toxic paralysis is the popular name given in Western Australia to the disease botulism which affects cattle, sheep and horses. It is known to be caused by the ingestion of a toxin or poison produced by the germ *Bacillus botulinus* in decaying organic matter. Sheep, cattle and horses are very susceptible to this poison, poultry less so and pigs and dogs are quite immune. Botulism in cattle has been known for many years in many parts of the world but in sheep the disease rarely causes serious losses except in Western Australia, and even in this State the disease in sheep was not recorded until 1928 by Bennetts.* Since that time its incidence has increased rapidly each year until in the summers of 1932-3 and 1934-5 it was considered to be responsible for far greater losses than all other diseases affecting sheep in Western Australia. The very much heavier losses during the last few years is believed to be due to the rapid spread and increase in the numbers of rabbits in the wheat-belt during that time. The larger number of rabbits would not only provide more available carcases and spread the germ itself but would seriously intensify the natural pasture deficiency of the summer period by their powers of competition with the sheep for the grazing and by their habit of selecting the best of the herbage.

The disease affecting sheep occurs throughout the wheat-belt and the Great Southern portions of the State. The dairy-belt and the north-west pastoral areas are so far quite free from the trouble. It occurs only in the dry summer months

* Bennetts, H. W.: Toxic Paralysis of Sheep, Jn. Dept. Agric., W.A., 5: 108 (1928).

of the year from November to May and disappears rapidly and completely with the advent of winter rains and green feed.

Sheep of all breeds and at all ages are equally affected, though the heaviest losses are undoubtedly from pregnant and lambing ewes.

Symptoms.

The symptoms are a stiff, stilted gait, disinclination to move more than small distances; drooping of the head when standing; and in bad cases profuse dribbling from the mouth and laboured and spasmodic breathing. These symptoms may last from a few hours to several days. Death usually ensues but a percentage of animals recover completely. There are no obvious post mortem appearances and there is no known cure, though mild cases may be helped by yarding and hand-feeding and watering. This is probably due largely to the fact that movement on the part of the sheep is reduced to a minimum in this way. Farmers are apt to confuse these symptoms with those of certain other disorders such as stinkwort poisoning and pregnancy toxaemia (fatty liver) and there is little doubt that in some cases losses attributed to toxic paralysis have been in reality due to some other disease.

Sources of Infection.

As stated earlier the cause of the disease is known to be the ingestion by the sheep of a poison produced by the germ *Bacillus botulinus*. This germ is a normal and quite harmless inhabitant of many soils and may occur in the intestines of healthy living animals such as sheep and rabbits. It is not until the rabbit dies that the germ multiplies and produces the poison in the decaying carcase. Such rabbit carcases which lie about the paddocks and are eaten by the sheep in the summer period represent the principal source of the disease. It must be emphasised that their effect in producing toxic paralysis is in no way connected with the phosphorus baits which are frequently used to kill them.

Though infected rabbit carcases are undoubtedly the main source of the disease there is now some evidence that certain water supplies, notably dirty soaks and wells, may also contain the poison and perhaps be responsible for losses from toxic paralysis. This is a very important question and is receiving further attention by the Veterinary Pathologist of the Department of Agriculture (Dr. H. W. Bennetts).

The depraved appetite or craving which impels sheep to consume these decaying carcases, so foreign to the normal diet of sheep, is termed sarcophagia (flesh-eating) and is believed to be due to the very poor dry feed conditions of the late summer months. Exactly what it is about this poor summer feed which is responsible for the sheep's abnormal craving is not yet fully understood, though it is known that the craving disappears with remarkable rapidity as soon as green feed becomes available. It is evident that there must be some marked difference or differences between the old fibrous herbage of the late summer and the young green pasture of the autumn which can be correlated with the incidence of the depraved appetite. From chemical analyses the outstanding differences appeared to be the very much lower phosphorus and protein contents of the summer herbage. A general recommendation for farmers to feed a good phosphatic lick throughout the summer months was therefore made by the Department of Agriculture. Support was given to this recommendation by work in parts of South Africa where remarkable results had accrued in preventing a disease in cattle identical with toxic paralysis by the use of bonemeal or dicalcic phosphate.

Results with sheep in Western Australia, however, were not nearly so conclusive. Some farmers claimed good results from the use of dicalcic phosphate and a few are still doing so. On the other hand others maintain that they have had no benefit from the use of any phosphatic lick, even when consumed in large amounts. Some farmers claimed that the use of conserved feeding stuffs such as hay, silage or oats reduced the incidence of the disease, while others appear to have received no benefit in this regard.

However, the evidence available was so conflicting and there was such a marked absence of really reliable information that in 1933 the Department of Agriculture commenced an investigation of the whole problem.

Meckering Experiments, 1933–4.

The grazing of a farm at Meckering, where severe losses from toxic paralysis had occurred, was leased, and early in the summer of 1933-4 experiments were started.

Aims.

The experiments were designed to ascertain the effects of feeding to sheep, as additions to the summer grazing, a phosphatic lick and various food supplements on—

(1) the incidence and control of the depraved appetite (sarcophagia);

(2) the blood phosphorus levels;

(3) the growth and wool yields.

In addition an investigation into the composition and feeding value of wheat-belt pastures and stubbles was commenced. These results, together with the effect of the supplements on growth and wool yield, will be reported in later articles.

Lay-out of Experiments.

A flock of 100 merino weaners aged 4-6 months were weighed and divided into five even groups of twenty. The treatments of the groups were as follows:—

Group 1.—Control—summer grazing alone.

Group 2.—Grazing plus dicalcic lick *ad libitum*.

Group 3.—Grazing plus 1lb. oats per sheep per day.

Group 4.—Grazing plus 1lb. linseed cake per sheep per day.

Group 5.—Grazing plus ¼lb. chaff plus ¼lb. oats per sheep per day, plus dicalcic lick *ad libitum*.

The sheep were run together on ordinary wheat belt summer grazing (mainly wheaten stubble) in the daytime. Each evening (except Sundays) they were brought into yards, divided into their groups and given their food supplements. At dawn each morning they were turned out to graze once more.

Feeding commenced on 8th December, 1933, and was continued until 2nd May, 1934. For most of the period the food supplements were fully consumed, though the amounts fell off during April when green feed became more plentiful. The ration of linseed cake in Group 4 was changed to a ¼lb. oats and ¼lb. meatmeal per sheep per day at the end of February, 1934. The meatmeal proved definitely unpalatable and only small amounts were consumed. (It must be noted that in the following summer the same sheep, as hoggets, quickly became accustomed to the meatmeal and ate their full ration readily.)

The phosphatic lick used was dicalcic lick of the following composition:—

Dicalcic phosphate	45 parts
Common salt	40 parts
Molasses	5 parts
Water	10 parts

It contained 18 per cent. P_2O_5 and was readily eaten by Groups 2 and 5. The average consumption during this period was about ½oz. of the lick (3 gm. P_2O_5) per sheep per day in both groups . In March and April green feed had appeared and the amount of lick consumed fell off in each group.

Depraved Appetite.

In order to test for depraved appetite in the experimental sheep, rabbit carcases were exposed to the different groups in small yards at frequent intervals and observations made as to the interest shown in them. Dried gutted carcases were used so as to minimise the risk of the carcases being infected with the toxic paralysis poison. Tests showed that neither moist fresh carcases nor putrid carcases were attractive to any of the sheep, nor would any of them touch either fresh or old bones. It was soon evident that the dried flesh was the most attractive part of the rabbit carcases, i.e., their depraved appetite was a true sarcophagia.

Tests with the dried carcases were negative during December and January but early in February four of the control group and one of the lick fed group ate the carcases. A fortnight later five of the controls on dry grazing alone and two of the lick fed sheep showed active sarcophagia but still none of the sheep in groups 3, 4, and 5, receiving oats, linseed cake or chaff and oats would touch the carcases.

Early in March, just after this test, very heavy rains fell which immediately brought on green feed, and within a fortnight all signs of depraved appetite had disappeared in all sheep.

There were no losses from toxic paralysis in the experimental sheep and remarkably few anywhere in the State, due to the abnormally early rains and short dry period.

Blood Phosphorus Levels.

Workers in South Africa and elsewhere have shown that phosphorus deficiency in the diet is associated with low levels of inorganic phosphorus in the blood. Blood phosphorus determinations should therefore represent a quick and reliable means of diagnosing phosphorus deficiency or sufficiency. Sheep on an ample phosphorus intake should, according to the South African workers, contain about 4.5 or more milligrams of inorganic phosphorus per 100 c.c. of whole blood. The level falls to about 3—4 mgs. on a fairly low intake, and to 2—3 mgs., or even less, under conditions of acute phosphorus deficiency.

A series of blood phosphorus determinations were therefore carried out at about monthly intervals throughout the year to ascertain—

(1) if any fall from normal values occurred during the late summer period with sheep on dry grazing alone, and

(2) if the supplementary feeding with a phosphatic lick, etc., produced any changes in these values.

The results are given in Table 1. Each figure represents the mean of five typical sheep from each group.

Table 1.

Blood Phosphorus Levels of Sheep at Meckering.

Mgs. inorganic P per 100 *c.c. whole blood.*

——	5-1-34.	8-2-34.	16-3-34.	20-4-34.	1-6-34.	16-7-34.	14-9-34.	19-10-34.	4-12-34.
Group 1—Control ...	6·2	5·2	6·7	5·0	7·6	5·9	5·7	4·8	4·8
Group 2—Lick ...	5·6	5·8	5·8	4·9	7·9	6·1	6·1	4·7	4·9
Group 4—Linseed cake	7·8	7·2	7·2	4·9	7·0	5·5	4·8	4·0	4·7
Group 5—Chaff and oats and lick ...	...	...	5·9	5·1	8·5	6·1	6·0	5·2	4·8

From the figures in Table 1 it is evident that although considerable variation exists, there are no abnormally low figures at any time and no indications of phosphorus deficiency even in the control group in January and February.

However, the summer of 1933-34 was so short that the results could not be taken as representing a typical summer period. It is possible that a longer and drier summer might produce lower blood phosphorus levels.

Meckering Experiments, 1934–5.

The results of the 1933-4 experiments indicated strongly that the nutritional conditions in the wheat belt of Western Australia differ markedly from those in South Africa and that the feeding of phosphatic licks, though giving some control in the early part of the season, could not be regarded as a fully effective means of controlling the depraved appetite. The craving appeared to be completely controlled, however, by the feeding of such materials as oats, linseed and chaff. Nevertheless the summer was so abnormally short and there were such small losses from toxic paralysis anywhere in the State in that year that it was imperative to carry out further work in a more normal season. Accordingly a further series of experiments were started on the same farm at Meckering early in the summer of 1934-5.

Lay-out.

The same experimental technique was employed as in the previous year. A flock of 84 merino hoggets aged 16-18 months were weighed and divided into seven even groups of 12. The treatments of the groups were as follows:—

Group 1.—Control—summer grazing alone.
Group 2.—Grazing plus dicalcic lick *ad libitum.*
Group 3. Grazing plus salt *ad libitum.*
Group 4.—Grazing plus ½lb. wheat per sheep per day plus dicalcic lick *ad libitum.*
Group 5.—Grazing plus 2oz. meat meal per sheep per day.
Group 6.—Grazing plus ½lb. chaff plus dicalcic lick *ad libitum.*
Group 7.—Grazing alone but not kept in yards at night.

Feeding commenced on 10th December, 1934, and was continued until 13th June, 1935. The grazing during most of this period was dry, natural pasture with some oaten stubble. A small amount of green picking was available during May and June.

The rations were fully consumed throughout the period. It is interesting to note that the meatmeal was readily eaten by all except two members of Group 5. This is in contrast to the definite distaste exhibited by weaners the previous summer.

The dicalcic lick was evidently very palatable. The average consumption was the very high one of about 1 ounce of the lick per sheep per day (7 gm. P_2O_5) in Group 2, $^3/_4$ ounce (5 gm. P_2O_5) per sheep per day in Group 4 and about ½ ounce (3 gm. P_2O_5) per sheep per day in Group 6.

The salt consumption in Group 3 varied from ½-4/5 ounce per sheep per day. It may be noted that the amount of salt consumed by the Lick Group in the form of dicalcic lick was very similar to the amount actually taken by the Salt Group.

Depraved Appetite Tests.

No evidence of depraved appetite could be demonstrated until the end of January when three sheep in the control group, five of the salt group, two of the meatmeal group and one of the chaff group showed an active interest in the dried carcases.

The lick group, the wheat fed group and Group 7, which had no supplement but was turned out to graze at night, were so far free from sarcophagia. During February and March a more general depraved appetite developed in all groups except Group 4 which received ½ lb. wheat per day plus the lick. The dicalcic lick consumed by Group 2 no longer gave the control apparent in the early part of the summer.

During this period tests for depraved appetite with materials other than dried rabbit carcases were made. As in the previous summer the sheep displayed no interest in old or fresh bones (in fresh meat) or in moist, putrid carcases. Practically all the sheep of the control, the salt and lick groups ate dried rabbit meat but only one sheep in each of the groups receiving wheat and chaff and none of the meatmeal fed sheep ate the meat when tested on 28/3/35.

Dried rabbit droppings were readily eaten by practically every sheep in each group when tested on 27/2/35.

The dry weather continued and by the middle of April practically the whole of the sheep both in the control, the lick and the salt fed groups and nearly half the sheep in the meatmeal and chaff fed groups had developed the craving. With the exception of one sheep the group receiving the ration of wheat plus lick remained free from craving throughout the whole summer.

Following on a light fall of rain a small amount of green picking became available to the sheep during May and the sarcophagia fell away slightly in all affected groups. Early in June with the definite advent of green feed all signs of it rapidly disappeared.

Losses from Toxic Paralysis.

Although there were no losses from toxic paralysis in the 1933-4 experimental sheep, the losses in the 1934-5 experiments were very heavy, particularly in the salt group (Group 3). It is strongly suspected that some at least of these losses were from infected water supply (soaks) and not from rabbit carcases. A number of sheep were affected with toxic paralysis but recovered after a few days with yarding and hand-feeding and watering.

The actual losses in the different groups were as follow:—

Group 1—Control	2
Group 2—Lick	nil
Group 3—Salt	4
Group 4—Wheat	2
Group 5—Meatmeal	1
Group 6—Chaff	1
Group 7—Grazing control ..	2

Blood Phosphorus Levels.

The determination of the blood phosphorus levels of the experimental sheep, commenced in December, 1933, was continued throughout the summer of 1934-5. The results are given in Table 2. The figures in the table represent the average of all the sheep in each of the groups tested, namely 12 sheep in Group 2, 12, and later 11, sheep in Group 5 and 12, and later 10, sheep in Group 1. The smaller numbers in the last two groups are due to losses from toxic paralysis.

Table 2.

Blood Phosphorus Levels at Sheep at Meckering.

Mgs. inorganic P per 100 c.c. whole blood.

——	4-12-34.	16-1-35.	11-2-35.	12-3-35.	28-3-35.	9-4-35.	9-5-35.	23-5-35.	14-6-35.	3-7-35.
Group 1—Controls	4·7	4·7	5·0	5·0	5·4	4·8	5·2	5·2	5·1	5·2
Group 2—Lick	5·1	4·3	5·5	4·5	5·9	5·2	5·9	6·4	5·9	4·9
Group 5—Meatmeal	4·7	4·8	4·6	5·1	5·2	4·8	5·5	5·8	4·6	5·1

As in the previous summer there is no fall in the levels of inorganic phosphorus in the blood of the control sheep on dry grazing alone in the summer period. Even in March and April when the dry conditions were at their worst there is no evidence of phosphorus deficiency. The supplementary feeding of dicalcic lick and of meatmeal in Groups 2 and 5, respectively, gave no consistent increases in the blood phosphorus levels, though on occasions the very large amounts of lick consumed raised the blood phosphorus content to abnormally high levels. For instance, sheep Nos. 55 and 23 of the lick group had respectively no less than 9.6 and 9.0 mgs. phosphorus per 100 c.c. of their blood when tested a few hours after the consumption of the lick on 28/3/35.

Experiments at Beverley.

During the summers of 1933-4 and 1934-5 experiments of a similar nature to the Meckering experiments with mated ewes and with weaner wethers were conducted at the Avondale State Farm, where no losses from toxic paralysis had occurred. Blood phosphorus determinations were also carried out in the two summers.

During 1933-4 no depraved appetite, as evidenced by liking for rabbit carcases, could be demonstrated at any time. Even in the 1934-5 summer when the craving became acute at Meckering, little interest in carcases was shown at Beverley. Three of the control sheep on dry grazing alone and one of the dicalcic lick fed sheep nibbled slightly at exposed carcases. No interest at all was shown by the sheep receiving supplementary rations of wheat, meatmeal and silage. There were no losses from the disease.

As at Meckering the blood phosphorus figures showed no significant fall from normal values in the summer in either year, and there was therefore no indication of phosphorus deficiency. The actual blood phosphorus levels in the long 1934-5 summer at Avondale were closely similar to those at Meckering. During the previous winter at Beverley pregnant ewes, while on green feed containing ample phosphorus, exhibited marked falls in their inorganic blood phosphorus levels just before lambing. This fall lasted for varying periods afterwards. Many of the ewes did not return to normal values for several months.

General Conclusions from the Experiments.

A study of the results of the second year's work, in conjunction with those of the previous year, forces the conclusion that phosphorus deficiency is not the principal factor in inducing toxic paralysis in sheep. Nor can the feeding of dicalcic phosphate, even in large quantities be now regarded as an effective prophylactic under conditions similar to those at Meckering. The supplementary feeding of such materials as wheat, meatmeal, and chaff from January to May may be expected to give, in general, some control of the depraved appetite, but the procedure is costly, and is not fully effective. Even in the group at Meckering receiving the ration of ½ lb. wheat per sheep per day, plus lick, which showed practically no interest in rabbit carcases, two sheep out of a total of twelve, died of toxic paralysis. It is possible, however, as indicated earlier, that these two sheep obtained the poison from an infected water supply, a source of infection which the farmer can readily eliminate.

Future Work.

From the work so far carried out it is obvious that the problem in this State is a very difficult one, and not the straight-forward phosphorus deficiency, responding to phosphatic licks, which appears to explain botulism in cattle in South Africa. The work carried out so far has been mainly valuable in eliminating earlier misconceptions, and in giving leads for future work.

Next summer a very extensive programme of work is planned, including large scale field experiments with a preventive vaccine; further nutritional and biochemical studies on the nature and control of the sarcophagia: and more detailed studies on the bacteriology and pathology of the disease.

Recommendations.

The work has shown that in the meantime farmers can do a considerable amount to improve the position for themselves. There are three main ways in which this can be done.

1. *Rabbit Control.*—There is no doubt that effective rabbit control by netting, poisoning, fumigating etc., is primary and fundamental to the whole problem. It is reasonable to claim that with no rabbits there would be little or no toxic paralysis in sheep. All carcases should be regularly picked up and either burned, buried, or fed to pigs. In this way the main source of infection will be removed, and the quantity and quality of available pasture increased. Water supplies, particularly open soaks, should also be regularly cleaned out.

2. *Pasture Improvement.*—Very much greater attention should be paid to pasture improvement. Pasture production is the most neglected phase of farming on most farms in the toxic paralysis areas. Topdressing with superphosphate and the introduction of better and more productive species such as "Dwalganup" subterranean clover and others will greatly improve the nutritive conditions of the sheep. With better feed conditions they will be less interested in rabbit carcases, and therefore less likely to contract the disease.

3. *Supplementary Feeding.*—For the same reason a certain level of supplementary feeding during the late summer months, particularly with small rations of wheat, oats, lupins, or peas, at about ½ lb. per sheep per day, will tend to minimise the trouble. At the same time it must be pointed out that such feeding is very costly and may be economically unsound for ordinary flock sheep except where rabbits are very bad and losses likely to be severe.

MAIZE FERTILISER TRIALS, 1934-35.

H. G. Elliott,

Agricultural Adviser (Dairy Branch), Department of Agriculture.

Maize Fertiliser Trials were continued at eight centres throughout the South-West during the season 1934-35.

As in the past, Cuming Smith and Mt. Myell Farmers' Fertilisers, Ltd., generously agreed to donate half the fertilisers required for the experiments.

In view of past experience the objects of the experiments were threefold:—

(1) To ascertain whether sulphate of ammonia and potash were required in addition to superphosphate.

(2) To ascertain what dressing of superphosphate was most economical.

(3) To ascertain whether it was necessary to add sulphate of ammonia to a dressing of 3 cwts. superphosphate for economical returns.

The fertiliser mixtures are shown below with the abbreviated nomenclature adopted in referring to these fertilisers in the results.

S2—Superphosphate 2 cwts. per acre (Control).

S3—Superphosphate 3 cwts. per acre.

S4—Superphosphate 4 cwts. per acre.

S2A1—Superphosphate 2 cwts. per acre + sulphate of ammonia 1 cwt. per acre.

S3A1—Superphosphate 3 cwts + sulphate of ammonia 1 cwt. per acre.

S2A2—Superphosphate 2 cwts. + sulphate of ammonia 2 cwts. per acre.

S2A2K1—Superphosphate 2 cwts. + sulphate of ammonia 2 cwts. per acre + sulphate of potash 1 cwt. per acre.

S2A3—Superphosphate 2 cwts. + sulphate of ammonia 3 cwts. per acre.

Lay-out of Plots.—Each plot was of one-twentieth acre and each treatment was replicated three times. In all there was a total of 30 plots.

NON-IRRIGATED TRIALS.

Supervised by H. G. Elliott, Agricultural Adviser.

1. *Messrs. Bee Bros., Keysbrook.*

Soil.—Brown sandy loam overlaying clay. This was old subterranean clover land originally carrying redgum and jarrah.

Cultivation.—Soil prepared by spring ploughing and harrowing, being reworked and ploughed prior to planting.

Method of Sowing, etc.—Fertiliser applied to every third furrow and lightly covered with soil, and the seed sown to a depth of 2½ inches.

Rate of Seeding.—30 lbs. per acre.

Variety.—"Hickory King."

Distance between Rows.—26 rows per 20 yards.

Weights taken on 21st January, 1935.

TABLE 1.—*Results of Maize Fertiliser Trial.*

Bee Bros., Keysbrook.

Fertilizer.	*Cost Fertilizer per acre, plus Freight.	Average Yield per acre.	Percentage Yield.	Value of Yield per acre at 15s. per ton.	Value of Crop per acre, less Cost Fertilizer and Freight.
	£ s. d.	tons.		£ s. d.	£ s. d.
S2	0 9 3	8·11	100	6 1 8	5 12 5
S2, A1	1 1 5	9·05	111	6 15 9	5 14 4
S2, A2	1 13 6	8·11	100	6 1 8	4 8 2
S2, A2, K1	2 9 5	8·43	104	6 6 5	3 17 0
S2, A3	2 5 8	6·55	81	4 18 2	2 12 6
S2	0 9 3	8·11	100	6 1 8	5 12 5
S3	0 13 11	6·55	81	4 18 2	4 4 3
S4	0 18 6	9·67	119	7 4 9	6 6 3
S3	0 13 11	6·55	100	4 18 2	4 4 3
S3, A2	1 18 2	6·71	103	5 0 7	3 2 5

* Fertiliser freights, North Fremantle to Keysbrook—7½d. per cwt.; Super—£4 per ton; Sulphate of Ammonia—£11 10s. per ton; Sulphate of Potash—£15 5s. per ton.

Note.—All plots suffered from drought conditions.

2. *L. Stiles, Vasse.*

Soil.—Varying from light sandy to red loamy soil originally carrying redgum and jarrah. Land previously growing subterranean clover.

Width between Rows.—30 inches.

Rate of Seeding.—30 lbs. per acre.

Variety.—"Hickory King."

Germination.—Generally good, patch one end, growth generally uneven.

TABLE 2.—*Results of Maize Fertiliser Trial.*

L. Stiles, Vasse.

Fertilizer.	*Cost Fertilizer per acre, plus Freight.	Average Yield per acre.	Percentage Yield.	Value of Yield per acre at 15s. per ton.	Value of Crop per acre, less Cost Fertilizer and Freight.
	£ s. d.	tons.		£ s. d.	£ s. d.
S2	0 9 3	4·86	100	3 12 10	3 3 7
S2, A1	1 1 5	4·71	96	3 10 7	2 9 2
S2, A2	1 13 6	7·40	152	5 11 0	3 17 6
S2, A2, K1	2 9 5	5·63	115	4 4 3	1 14 10
S2, A3	2 5 8	5·40	111	4 1 0	1 15 4
S2	0 9 3	4·86	100	3 12 10	3 3 7
S3	0 13 11	4·64	95	3 9 7	2 15 8
S4	0 18 6	3·97	82	2 19 7	2 1 1
S3	0 13 11	4·64	100	3 9 7	2 15 8
S3, A2	1 18 2	4·24	91	3 3 7	1 5 5

* Fertiliser Freights, Picton Junction to Vasse Siding—7½d. per cwt.

Note.—All plots suffered from drought conditions during growth.

3. *J. H. Oldfield, Forest Grove.*

Soil.—Light chocolate sandy loam originally timbered with redgum and karri. Land previously growing subterranean clover.

Preparation of Soil.—Ploughed and harrowed in the spring, reworked and ploughed at time of planting. Intertillage was carried out during the growing period.

Rate of Seeding.—The seed was planted at the rate of 30 lbs. per acre and the rows were 36 inches apart.

Variety.—"Hickory King."

Germination.—Generally good.

TABLE 3.—*Results of Maize Fertiliser Trial.*

J. H. Oldfield, Forest Grove.

Fertilizer.	*Cost Fertilizer per acre, plus Freight.	Average Yield per acre.	Percentage Yield.	Value of Yield per acre at 15s. per ton.	Value of Crop per acre, less Cost Fertilizer and Freight.
	£ s. d.	tons.		£ s. d.	£ s. d.
S2	0 9 2	4·33	100	3 4 11	2 15 9
S2, A1	1 1 3	4·46	103	3 7 2	2 5 11
S2, A2	1 13 4	5·51	127	4 2 7	2 9 3
S2, A2, K1	2 9 0	5·86	136	4 7 10	1 18 10
S2, A3	2 5 3	7·28	168	5 9 2	3 3 11
S2	0 9 2	4·33	100	3 4 11	2 15 9
S3	0 13 8	4·63	107	3 9 5	2 15 9
S4	0 18 4	4·57	106	3 8 6	2 10 2
S3	0 13 8	4·63	100	3 9 5	2 15 9
S3, A1	1 18 0	5·75	125	4 6 2	2 8 2

* Fertiliser Freights, Picton Junction to Forest Grove—7d. per cwt.

Note.—Plots suffered from drought conditions.

4. *Reading Bros., Vasse.*

Soil.—Light sandy loam previously growing drooping flowered clover.

Preparation of Soil.—Ploughed and harrowed in spring, further cultivation and ploughing at time of planting. Cultivation carried out during growing period.

Seed.—"Hickory King" at 30 lbs. per acre.

Germination.—Good.

TABLE 4.—*Results of Maize Fertiliser Trial.*

Reading Bros., Vasse.

Fertilizer.	*Cost Fertilizer per acre, plus Freight.	Average Yield per acre.	Percentage Yield.	Value of Yield per acre at 15s. per ton.	Value of Crop per acre, less Cost Fertilizer and Freight.
	£ s. d.	tons.		£ s. d.	£ s. d.
S2	0 9 3	6·92	100	5 3 9	4 14 6
S2, A1	1 1 5	4·99	71	3 14 9	2 13 4
S2, A2	1 13 6	8·25	119	6 3 8	4 10 2
S2, A2, K1	2 9 5	7·50	110	5 12 6	3 3 1
S2, A3	2 5 8	7·00	101	5 5 0	2 19 4
S2	0 9 3	6·92	100	5 3 9	4 14 6
S3	0 13 11	7·47	109	5 12 0	4 18 1
S4	0 18 6	7·34	106	5 11 1	4 12 7
S3	0 13 11	7·47	100	5 12 0	4 18 1
S3, A1	1 18 2	7·08	95	5 6 2	3 10 0

* Fertiliser Freights, Piction Junction to Vasse—7½d. per cwt.

5. *E. C. Melville, Wonnerup.*

Soil.—Grey sandy loam, new land, originally carrying paper-bark and redgum.

Soil Preparation.—Ploughed and cross-ploughed, and harrowed. Reploughed at time of planting, inter-tillage being carried out during the growing period.

Seed.—"Hickory King" at the rate of 30 lbs. per acre.

TABLE 5.—*Results of Maize Fertiliser Trial.*

E. C. Melville, Wonnerup.

Fertilizer.	*Cost Fertilizer per acre, plus Freight.	Average Yield per acre.	Percentage Yield.	Value of Yield per acre at 15s. per ton.	Value of Crop per acre, less Cost Fertilizer and Freight.
	£ s. d.	tons.		£ s. d.	£ s. d.
S2	0 9 0	2·18	100	1 12 8	1 3 8
S2, A1	1 1 0	3·13	143	2 6 8	1 5 8
S2, A2	1 13 0	4·26	198	3 3 10	1 10 10
S2, A2, K1	2 8 9	6·63	300	4 19 5	2 10 8
S2, A3	2 4 11	6·93	317	5 3 10	2 18 11
S2	0 9 0	2·18	100	1 12 8	1 3 8
S3	0 13 6	2·00	96	1 10 0	0 16 6
S4	0 18 0	3·38	155	2 10 8	1 12 8
S3	0 13 6	2·00	100	1 10 0	0 16 6
S3, A1	1 17 8	4·64	232	3 9 7	1 11 11

* Fertiliser Freight, Piction Junction to Wonnerup—6d. per cwt.

TABLE 6.—*Average Results of the five Experiments on Non-Irrigated Land.*

Fertilizer.	Cost Fertilizer per acre, plus Freight.	Average Yield per acre.	Percentage Yield.	Value of Yield per acre at 15s. per ton.	Value of Crop per acre, less Cost Fertilizer and Freight.
	£ s. d.	tons.		£ s. d.	£ s. d.
S2	0 9 2	5·28	100	4 0 2	3 11 0
S2, A1	1 1 4	5·20	92	3 18 0	1 16 8
S2, A2	1 13 4	6·71	127	5 0 7	3 7 3
S2, A2, K1	2 9 2	6·81	129	5 2 1	2 12 11
S2, A3	2 5 5	6·63	126	4 19 5	2 14 0
S2	0 9 2	5·28	100	4 0 2	3 11 0
S3	0 13 9	5·06	96	3 15 10	3 2 1
S4	0 18 4	5·79	110	4 6 9	3 8 5
S3	0 13 9	5·06	100	3 15 10	3 2 1
S3, A1	1 18 0	5·68	112	4 5 2	2 7 2

As was the case with the 1933-34 season on non-irrigated trials, the summer generally was quite unfavourable to heavy yields, owing to the extreme dryness.

TRIALS ON IRRIGATED LANDS.

Supervised by C. Giles, Dairy Instructor.

7. *F. S. Morris, Harvey.*

Soil.—Black peaty loam; old potato and clover land.

Germination.—Good.

Seed.—"Hickory King" at the rate of 60 lbs. per acre.

Date planted.—From 25th January to 4th February.

Date weighed.—10th April, 1935.

TABLE 7.—*Results of Maize Fertiliser Trial.*

F. S. Morris, Harvey.

Fertilizer.	*Cost Fertilizer per acre, plus Freight.	Average Yield per acre.	Percentage Yield.	Value of Yield per acre at 15s. per ton.	Value of Crop per acre, less Cost Fertilizer and Freight
	£ s. d.	tons.		£ s. d.	£ s. d.
S2	0 8 9	21·05	100	15 15 8	15 6 11
S2, A1	1 0 8	24·04	114	18 0 7	16 19 11
S2, A2	1 12 6	26·17	124	19 12 6	18 0 0
S2, A2, K1	2 8 2	41·11	195	30 16 8	28 8 6
S2, A3	2 4 5	35·98	171	26 19 8	24 15 3
S2	0 8 9	21·05	100	15 15 8	15 6 11
S3	0 13 2	24·11	114	18 1 7	17 8 5
S4	0 17 6	22·10	105	16 11 6	15 14 0
S3	0 13 2	24·11	100	18 1 7	17 8 5
S3, A1	1 5 1	22·10	92	16 11 6	15 6 5

* Fertiliser Freight, Picton Junction to Harvey—4½d. per cwt.

8. *A. S. Warburton, Brunswick.*

Soil.—Grey sandy loam originally carrying redgum and jarrah. Old clover pasture.

Date planted.—16th November.

Germination.—Good.

Weights taken on 26th March, 1935.

Seed.—"Hickory King" at the rate of 30 lbs. per acre.

General.—Average height of crop 7 to 8 feet with growth fairly even, with the exception of the eastern end, which suffered rather severely from the easterly winds. The plot showed signs of being over-watered.

TABLE 8.—*Results of Maize Fertiliser Trial.*

A. S. Warburton, Brunswick.

Fertilizer.	*Cost Fertilizer per acre, plus Freight.	Average Yield per acre.	Percentage Yield.	Value of Yield per acre at 15s. per ton.	Value of Crop per acre, less Cost Fertilizer and Freight.
	£ s. d.	tons.		£ s. d.	£ s. d.
S2	0 8 7	16·42	100	12 6 3	11 17 8
S2, A1	1 0 5	17·06	104	12 15 11	11 14 6
S2, A2	1 12 2	20·10	123	15 1 6	13 9 4
S2, A2, K1	2 7 9	21·00	128	15 15 0	13 7 3
S2, A3	2 4 0	19·19	117	14 6 9	12 2 9
S2	0 8 7	16·42	100	12 6 3	11 17 8
S3	0 12 11	16·22	99	12 3 3	11 10 4
S4	0 17 2	17·13	104	12 16 11	11 19 9
S3	0 12 11	16·22	100	12 3 3	11 10 4
S3, A1	1 4 9	18·03	111	13 10 5	12 5 8

* Freight Costs, Picton Junction to Brunswick—3½d. per cwt.

9. *J. A. B. Hay, Wagerup.*

Soil.—Clayey loam, originally timbered with redgum and jarrah. Old subterranean clover land.

Seed.—"Hickory King" at the rate of 30 lbs. per acre.

TABLE 9.—*Results of Maize Fertiliser Trial.*

J. A. B. Hay, Wagerup.

Fertilizer.	*Cost Fertilizer per acre, plus Freight.	Average Yield per acre.	Percentage Yield.	Value of Yield per acre at 15s. per ton.	Value of Crop per acre, less Cost Fertilizer and Freight.
	£ s. d.	tons.		£ s. d.	£ s. d.
S2	0 8 11	13·04	100	9 15 7	9 6 8
S2, A1	1 0 11	22·11	170	16 11 7	15 10 8
S2, A2	1 12 10	18·81	106	9 17 2	88 4 4
S2, A2, K1	2 8 7	15·19	117	11 7 10	7 19 3
S2, A3	2 4 10	20·19	155	15 2 10	12 18 0
S2	0 8 11	13·04	100	9 15 7	9 6 8
S3	13 5	12·73	98	9 10 11	8 17 6
S4	...	14·	110	10 13 3	9 15 5
S3	0 13 5	12·73	100	9 10 11	8 17 6
S3, A1	1 5 5	16·79	132	12 11 10	11 6 5

* Freight Costs, Piction Junction to Wagerup—5½d. per cwt.

TABLE 10.—*Average Results of the three Trials on Irrigated Lands.*

Fertilizer.	*Cost Fertilizer per acre, plus Freight.	Average Yield per acre.	Percentage Yield.	Value of Yield per acre at 15s. per ton.	Value of Crop per acre, less Cost Fertilizer and Freight.
	£ s. d.	tons.		£ s. d.	£ s. d.
S2	0 8 9	16·84	100	12 12 7	12 3 10
S2, A1	1 0 8	21·07	125	15 16 0	14 15 4
S2, A2	1 17 6	20·03	119	15 0 4	13 7 0
S2, A2, K1	2 8 2	25·77	153	19 6 6	17 18 4
S2, A3	2 4 5	25·12	149	18 16 9	16 12 4
S2	0 8 9	16·84	100	12 12 7	12 3 0
S3	0 13 2	17·69	105	13 5 5	12 12 3
S4	0 17 6	17·82	106	13 7 3	12 9 9
S3	0 13 2	17·69	100	13 5 5	12 12 3
S3, A1	1 5 1	18·97	108	14 4 6	13 1 5

* Average Fertiliser Freights—4½d. per cwt.

Results of the 1932-33 and 1933-34 Maize Fertiliser Trials were published in the June, 1934, issue of the "Journal of Agriculture."

CONCLUSIONS.

Although these fertiliser trials have been conducted for only one year, the results on the non-irrigated and irrigated plots have been fairly uniform, and it is believed that the following tentative conclusions can be drawn.

Non-irrigated Trials.

Table 6 which gives the summary of the yields and costs indicates:—

(a) On dry land which is unirrigated and which has carried subterranean clover for a number of years, the indications are that 2 cwts. of superphosphate per acre is the most economical fertiliser.

(b) On new land which is unirrigated, the indications are that sulphate of ammonia must be included in the mixture, which should be one of at least 2 cwts. superphosphate per acre with either 1 or 2 cwts. of sulphate of ammonia.

(c) It is doubtful whether the addition of sulphate of potash will be profitable for the growing of this crop on unirrigated areas.

(d) On old clover land it may not be profitable to add more than 2 cwts. superphosphate per acre.

Table 5 shows that, on new land at Wonnerup, both sulphate of ammonia and sulphate of potash added to the superphosphate were profitable.

Irrigated Trials.

Table 7 shows that on a peaty loam sulphate of ammonia added to the superphosphate in quantities from 1 to 3 cwts. was very profitable, and that the addition of 1 cwt. of sulphate of potash to the 2:2 mixture was most profitable.

Tables 8 and 9 show that, on sandy loam to clayey loam soils, sulphate of potash was not payable, but sulphate of ammonia gave profitable returns.

Table 10 indicates that no great variation occurred in yield or profit per acre from superphosphate applications varying from 2 to 4 cwts. per acre.

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THE SELECTION OF A DRAUGHT STALLION.

C. R. Toop, Veterinary Surgeon.

Department of Agriculture.

Excluding a few outstanding exceptions, it has to be admitted that the horses employed in farm work throughout Western Australia are not generally of a very high standard.

That this should be the case is not surprising, when the rapid progress which has occurred during the past ten or fifteen years in connection with the settlement and development of farm lands in this State is considered. During this period the demand for farm horses has far outstripped the supplies available, and as a consequence, any animal capable of performing work, irrespective of its suitability, has been pressed into service.

These unusual conditions no longer exist, and the time has arrived when many farmers should be in a position to breed their own requirements, and at the same time by mating selected draught sires with the best class of farm mares available to assist in a gradual grading up of the farm horses throughout the State. This would not only confer a benefit upon the individual, but upon the State as a whole, which for many years past has had to rely for its supplies of farm horses upon heavy importations from other parts of the Commonwealth.

When selecting a horse for breeding purposes, due regard should be given to the laws of inheritance, and it should be remembered that the characteristics of the parent, whether good or bad, may be transmitted to the progeny. Careful consideration should be given to two important aspects, viz.:—SOUNDNESS and CONFORMATION.

Soundness in the sense in which it is employed here, means freedom from certain hereditary diseases which may be transmitted to the progeny and which are calculated to interfere with the ability of the animal to perform useful work. Amongst the more common of these diseases may be included ringbone, sidebone, spavin, stringhalt cataract and roaring. The question of soundness is regarded in such a serious light that it has been dealt with in a special Act of Parliament known as the "Stallions Act," in accordance with the conditions of which no stallion may be used for stud purposes unless it has been subjected to a veterinary examination and has been certified as sound.

Conformation or "Make and Shape," is second only in importance to soundness. This is not merely an attribute of the show ring, or a question of fashion which varies according to the whims of the stud breeder, but on the contrary it goes far in determining the strength, activity, durability, and temperament of the animal. Upon conformation rests the capacity of the animal for work, the pace at which it is able to work, and the longevity of its working life. Faulty conformation may indicate an undesirable temperament, difficulty of control, lack of strength, slowness of movement, shortness of stride and predisposition to unsoundness.

The horse perfect in all respects is of extremely rare occurrence, but in making a choice the object should be to secure an animal which approaches the ideal as closely as possible. An animal showing outstanding or unpardonable faults, no matter how good he may be in all other respects, should at once be rejected.

A short description of the points of a draught horse of good conformation is given hereunder. A diagram which illustrates these is included. This description refers particularly to the Clydesdale breed, which in this State is employed

almost to the exclusion of all others in the production of draught animals. Any other breed must, however, in essential points, conform to the same standard. The photograph of an outstanding representative of the Clydesdale breed is reproduced.

Head.—The head should not be too large in proportion to the size of the body. The jowl should be broad, the muzzle not too finely tapered, and the nostrils wide and open. The forehead should be wide between the eyes tapering gently to the ears. The eye should be full and vigorous and well set out at the side of the head to command a good range of vision. The ears should be alert and as a general rule carried upright and forward. The space between the angles of the jaw should be wide.

In selecting horses, considerable attention is usually paid to the appearance of the head, for this provides an indication regarding the disposition and temperament of the animal and the ease with which it may be handled. For example, an animal with a small deep-set eye, or one which shows the white portion of the eye when looking backwards, may be found to be vicious and difficult to handle. An animal with lopping ears and a slack, pendulous under lip, has usually a lymphatic temperament.

Clydesdale Stallion "Great Count," rising 8 years, owned by Francis Bros., Maitland, South Australia.

An offer was made by Mr. David Adams, of Scotland, for the purchase of "Great Count," regarded by Mr. Adams as an outstanding sire, unequalled in Scotland to-day. A subsequent offer was made by Mr. Hugh McGregor, who desired to exhibit "Great Count" at the Glasgow Stallion Show. Both offers were refused by the owners, who considered if "Great Count" were in request for stud purposes in Scotland, he was too valuable to lose for Australia.

[Block by courtesy of Elder Smith & Co. Ltd.]

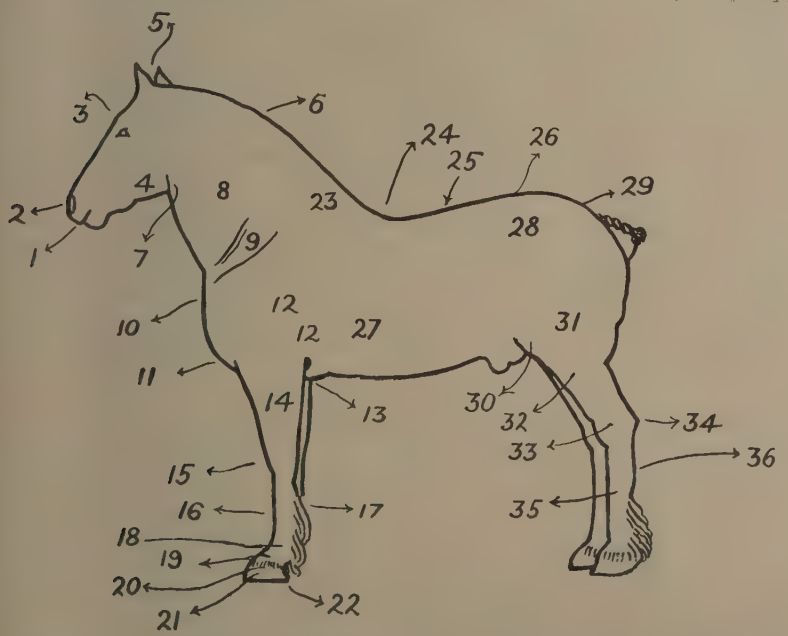
The head must be set on the neck at the correct angle as this has a good deal to do with the ease of control. An animal whose head is carried too high is sometimes most difficult to drive. When the head is set on at too low an angle, the animal hangs heavily on the bit and is described as being "heavy in the mouth." This type of head is usually large and heavy and is often associated with a short thick neck or "bull neck." Both of these are undesirable. Fortunately, the correct set on head is the one which presents the most pleasing appearance.

Neck.—The neck should always be of good length and well clothed with muscles, merging almost imperceptably into the shoulders and withers. The upper portion or crest should be gently arched. In stallions the crest often shows great development. The concave neck or "ewe-neck" which is a weak structure often associated with a head set on at too high an angle, is to be avoided. The short bulky "bull-neck" is equally objectionable.

Shoulders.—The shoulders should be long and well sloped back. A short upright shoulder is undesirable.

Forearm.—The forearm should be long and muscular, broad at the elbow, and gradually tapering towards the knee.

Knee.—The knee should be broad and flat and deep from front to back. Small knees and "calf" knees, *i.e.*, those which present a concave outline when viewed from the side, are undesirable.



1 Muzzle. 2 Nostril. 3 Forehead. 4 Jowl. 5 Poll. 6 Crest. 7 Angle of Jaw. 8 Neck. 9 Shoulder. 10 Point of Shoulder. 11 Brest. 12 Arm. 13 Elbow. 14 Forearm. 15 Knee. 16 Cannon. 17 Back Tendons. 18 Fetlock. 19 Pastern. 20 Coronet. 21 Hoof. 22 Heel. 23 Withers. 24 Back. 25 Loins. 26 Croup. 27 Ribs. 28 Point of Hip. 29 Root of Tail. 30 Stifle Joint. 31 Thigh. 32 Gaskin or Lower Thigh. 33 Hock. 34 Points of Hock. 35 Hind Cannon. 36 Back Tendons.

Cannons.—The cannon should be short. Viewed from the front it should be narrow, and from the side broad and flat with the back tendons well defined and set well back from the bone. The back tendons should fall in a perfectly straight line from knee to fetlock. Springing from the back of the cannon, there should be a good growth of fine straight hair which extends from the back of the knee to overhang the fetlock. This is known as the "feather." The heavy rounded "gummy" cannon in which the tendons are not well defined, and which is clothed with a luxuriant growth of coarse crinkled hair is to be avoided. An animal showing this conformation is said to have "round-bone" as contrasted with the "flat-bone" of the type described above. A construction of the tendons below the knee, known as "tied in" below the knee, is undesirable. Both types predispose to unsoundness.

Pasterns.—The pastern should be well sloped and of moderate length. Short upright pasterns are undesirable.

Coronet.—The coronet or hoof head should be well developed.

Feet.—The foot should be moderate to large in size, with plenty of space between the heel which should be low, and a well-developed frog. Small narrow feet ("donkey feet") should be avoided. The forelegs when viewed from the front should fall straight and true from the shoulders to the ground, and the toes should be turned neither in nor out. A neck of good length combined with a long well-sloped shoulder means a long and active stride. A short neck and straight shoulder is usually reflected in a short shuffling gait. A well-sloped shoulder and pastern, coupled with a large foot open at the heels, forms an ideal anticoncussive mechanism which serves to absorb shock when the foot makes contact with the ground, so protecting the limb from injury. There is no such protection afforded to the limb with a straight shoulder and pastern and blocky narrow feet. Where this conformation occurs there exists an especial predisposition to unsoundness, which manifests itself in the form of lameness when such an animal is required to work continuously on hard roads. A good illustration of the manner in which these two types of conformations operate is afforded by observing the action of the saddle horse. The experienced rider will appreciate the contrast between the long easy stride and comfortable action of the long necked animal with well-sloped shoulders and pasterns when compared with the short-stilted gait and proppy rough action of the animal with a short neck, upright shoulders and pasterns, and narrow feet.

Back.—The back should be short and straight with broad strong loins. Long backs and hollow "swampy" backs denote lack of strength, and are undesirable. The convex or "roached" back, though not pleasing to the eye, is consistent with great strength.

Body.—The body should be deep with well "sprung" (arched) ribs to allow ample space for the heart, lungs, and abdominal organs, the last rib extending to within a short distance—little more than a hand's breadth of the point of the hip. An animal showing this structure is said to be well ribbed or coupled up. Slackness in this region is undesirable.

Croup.—The croup should be long and broad, and should for preference approach the horizontal. A sloping croup, although not pleasing to the eye, is of no great detriment in draught horses. Where the slope is exaggerated, the animal is described as being "goose rumped."

Thigh.—The upper thigh should be well developed and muscular, tapering to the gaskin or second thigh which, although lean and hard, should show prominent bunches of muscle.

Hocks.—The hocks should be proportionally developed broad and lean. Small hocks and fleshy hocks should be avoided, both being subject to unsoundness. Hocks which are too much bent ("sickle hocks"), and those which are too straight, are also undesirable. When viewed from behind the hocks should approach each other. Wideness at the hocks is undesirable, and predisposes to "screwing" of the limb during locomotion. The hind limb from the hock to the ground, except that it is considerably longer, is similar in structure to the forelimb below the knee. The hind quarters as a whole, which provide the propelling power, should be deep, broad, and very muscular, and the inward set of the hocks is calculated to supply them with the maximum of thrust.

Action.—No stallion should be selected for breeding purposes until it has been seen in action. This is essential, and faults may become apparent that would otherwise remain undiscovered. Viewed from the front, he should approach with the head carried well and with an apparently measured tread, lifting the feet well off the ground and placing them down evenly and regularly. Any tendency towards closeness or wideness in front, and any evidence of lameness should be noted. Suspected lameness may be confirmed by making the animal trot. Viewed from the side the action should be even, the stride long and brisk, and the fore and hind actions should be in unison. Viewed from the rear the hocks should always be kept close together, moving in line with the body. There should be free movement at the hock and fetlock points. A short shuffling gait, closeness in front, which predisposes to "brushing" and wideness behind should be avoided. The animal showing symptoms of lameness should always be rejected, it being remembered that a horse, no matter how good a specimen he may appear to be, will be useless unless furnished with good sound legs.

To sum up, the horse of the desired conformation should possess a correctly proportioned and well set on head, a lengthy muscular neck, deep well-sloped shoulders, a short deep body, and broad deep muscular hindquarters set upon limbs possessing broad clean joints, short cannons composed of "flat-bone," well-sloped pasterns, and moderately large well-shaped feet, wide at the heels. The animal showing these characteristics, combined with good action, may be expected to give long and satisfactory service.

M. T. PADBURY TROPHY COMPETITION, 1934.

The following are the corrected figures for the entry of Mr. P. A. Strange for the above competition, the results of which were published in the June issue of this Journal:—

Competitor.	Address.	Rainfall during Growing Period.	Area Harvested.	Yield.		
				Gross.	Average per Acre.	Average per inch of Growing Period rain.
		points.	acres.	bus. lb.	bus. lb.	bus. lb.
Strange, P. A.	Yarding ...	716	264·0	4,830 26	18 18	2 33

MAIZE VARIETY TRIALS—1934-35.

H. G. ELLIOTT,

Agricultural Adviser, Department of Agriculture.

The above trials were conducted again this season. The results for the last year's trials were published in Volume 11 of this Journal, pages 335 and 513, and indicated that no deviation from the standard variety "Hickory King" could be recommended, although "Fitzroy" and "Small Leaming" varieties gave slightly higher yields of green material per acre. The objects of the trials were as follow:

1. To determine which variety, if any, would give higher yields of green material per acre than "Hickory King."
2. To determine where any of these varieties would be suitable for the producation of grain in Western Australia.

The following nine varieties were considered suitable for trial:—

1. *"Hickory King."*—Standard for green fodder in this State.
2. *"Small Leaming."*—For green fodder.
3. *"Fitzroy."*—For green fodder.
4. *"Silvermine."*—For green fodder.
5. *"Early White Dawn."*—For grain and early green feed.
6. *"Funk's Early Yellow Dent."*—For grain and green feed.
7. *"Early Morn."*—For grain and green fodder.
8. *"90 Day (Flint)."*—For grain and early green fodder.
9. *"Wellingrove."*—Green fodder.

Fertiliser.—The same fertiliser as for last season, *i.e.*, 3 cwts. of a mixture of super. 2½ parts and sulphate of ammonia 1 part.

The cost of the fertiliser was equally borne by Cuming Smith & Mt. Lyell Farmers' Fertilisers Ltd. and the Department of Agriculture.

Each variety was sown in triplicate in rows 30 inches apart, the rate of seeding in every case being 25 lb. per acre.

TABLE 1.—*Green Material.*

		Hickory King.	Silver-mine.	Wellingrove.	Fitzroy.	Small Leaming.
C. Peterson, Wokalup ...	Tons per acre	21·0	22·1	16·1	23·2	17·2
	Percentage Yield	100	105	77	110	82
H.C. Barnsby, Pemberton	Tons per acre	15·17	17·18	14·83	15·83	15·26
	Percentage Yield	100	115	97	104	101
F. C. Smith, Denmark ...	Tons per acre	46·0	44·3	38·2	49·7	33·85
	Percentage Yield	100	96	83	108	74
A. S. Hilditch, Northcliffe	Tons per acre	3·6	5·35	5·20	6·40	4·72
	Percentage Yield	100	148	144	176	130
S. F. Russell, Serpentine	Tons per acre	27·12	24·48	28·32	30·0	27·84
	Percentage Yield	100	89	104	111	103
A. Millar, Forest Grove ...	Tons per acre	5·06	5·57	6·33	5·66	5·13
	Percentage Yield	100	110	125	112	101

TABLE 2.—*Average Production of Six Trials*, 1934–35.

Variety.	Average Tons per acre.	Percentage Yield.
Hickory King	19·66	100
Silvermine	19·83	101
Wellingrove	18·16	92
Fitzroy	21·80	111
Small Leaming	17·33	83

C. Peterson, Wokalup.

Maize planted on a clayey loam originally carrying subterranean clover pasture. The land was well prepared, and planting carried out early in December. The plants were grown under irrigation, and weights taken 90 days after planting.

H. C. Barnsby, Pemberton.

This trial was carried out on a light loam running into a gravelly loam. Planting was finished on 26th November and, during the early growing period, intercultivation was carried out. Unfavourable weather conditions during December retarded the natural growth of the crop.

F. C. Smith, Denmark.

The maize varieties were sown on the side of a high karri hill, and the soil was a dark loam free from wet patches. The land lay fallowed for several weeks prior to planting. Seeding was carried out on 1st November, favourable weather conditions prevailing throughout, and the weights were taken on 11th March.

A. S. Hilditch, Northcliffe.

Planted on karri and redgum red loam on hillside. The land was fallowed in the autumn, and reploughed and planted on 20th October. Good germination was obtained but, owing to the drying out of the soil during the growing period, many plants died out.

S. F. Russell, Serpentine.

Grown on a heavy chocolate clay loam under irrigation. The height of the crop ranged from 5 feet with the "Wellingrove" variety and to 10 feet with the "Fitzroy."

A. Millar, Forest Grove.

This trial was planted on a karri red loam. The land was ploughed, disced and harrowed, and the seed and fertiliser sown in furrows after the second ploughing. The crop was very light yielding, owing to faulty germination, about 30 per cent.

TABLE 3.—*Green Material.*

		Hickory King.	Early White Dawn.	Early Morn.	Funk's Early Yellow Dent.	90 Day (Flint).
T. Giblett, Bridgetown ...	Tons per acre	13·3	17·7	11·8	13·5	12·0
	Percentage Yield	100	133	89	102	90
A. S. Warburton, Brunswick	Tons per acre	14·22	12·15	14·02	12·02	10·15
	Percentage Yield	100	85	99	84	71
S. O. Wilson, Pemberton	Tons per acre	12·9	15·33	12·52	15·11	9·7
	Percentage Yield	100	120	99	119	75
V. J. Rogers, Denmark ...	Tons per acre	35·5	22·7	21·5	28·0	43·0
	Percentage Yield	100	64	60	80	121
B. Brett, Dardanup ...	Tons per acre	15·74	10·49	14·10	14·43	14·43
	Percentage Yield	100	67	90	92	92
W. Fox, Witchcliffe ...	Tons per acre	8·35	9·007	8·797	8·708	8·72
	Percentage Yield	100	108	105	104	104

TABLE 4.—*Average Production of Six Trials.*

Variety.	Average Tons per acre.	Percentage Yield.
Hickory King	16·720	100
Early White Dawn	14·563	87
Early Morn	13·790	83
Funk's Early Yellow Dent	15·300	92
90 Day (Flint)	16·330	97

T. Giblett, Bridgetown.

Planted on two classes of soil, namely, red sandy loam and grey sand. Land ploughed on 20th November and cultivated and harrowed on 3rd December. The second ploughing was completed on 26th December with a further double cultivation, harrowing and rolling. The planting of all varieties took place on 29th December.

A. S. Warburton, Brunswick.

Planted on a sandy loam and irrigated. The growth on all plots was very uneven, and drainage was insufficient over some of the area.

S. O. Wilson, Pemberton.

This trial was conducted on red karri soil on a steep hillside. The first ploughing was carried out in May, the second in August, and finally the land was ploughed and planted on 11th October. Cultivation was carried out during the early growing stages. Very little growth was made during November on account of the cold weather conditions.

V. J. Rogers, Denmark.

Planted on damp karri land. Owing to the unusual wet season the plot became very wet, consequently affecting the growth of the crop during the early stages. The first ploughing was carried out in early winter, and the land was twice harrowed and disced before seeding on 5th November. The plot was cultivated twice during the early stages of growth.

B. Brett, Dardanup.

Grown on light sandy loam under irrigation. Planting was carried out on 5th December, and weights taken on 18th February.

W. Fox, Witchcliffe.

Planted on a grey loam originally timbered with jarrah and red gum. *Cultivation*: Disced and harrowed followed by a second ploughing at seeding time. Germination very poor.

TABLE 5.—*Average Production of Green Material and Percentage Yields for all Trials.*

Variety.	1934–35.			Average, 1933–34.—1934–35.		
	Average Yield.	Percentage Yield.	No. of Trials.	Average Yield.	Percentage Yield.	No. of Trials.
	Tons per acre.			Tons per acre.		
Hickory King	18·19	100	12	17·23	100	25
Fitzroy	21·80	120	6	19·87	115	13
Silvermine	19·83	109	6	17·32	100	12
Small Leaming	17·33	95	6	17·08	99	13
Wellingrove	18·16	100	6	16·16	94	13
Funk's Early Yellow Dent	15·30	84	6	17·74	91	12
90 Day (Flint)	16·33	90	6	14·45	84	11
Early Morn	13·79	76	6	13·50	78	12
Early White Dawn	14·56	80	6	13·40	78	11

The results obtained from the trials over a period of two years indicate that "Fitzroy" is slightly superior to "Hickory King" for a green fodder crop, but at present no deviation from the standard variety "Hickory King" can be recommended.

COST OF FEEDING COWS UNDER THE OFFICIAL AUSTRALIAN PURE BRED DAIRY CATTLE PRODUCTION TESTING SCHEME.

G. K. Baron-Hay, Superintendent of Dairying.

B. Williams, Agricultural Adviser.

In this article an attempt has been made to valuate the foods consumed by the pure bred herds under official test in Western Australia. The prices assigned to the various articles of produce are average prices and will vary somewhat with the different herds, especially for home-grown foodstuffs, such as maize, hay, lucerne, etc. This variation will be small for such foods as are purchased from external sources, and it is thought that the information contained in the tables given will supply a reasonably accurate estimation of the cost of feeding the various herds.

The actual prices used in arriving at these costs are shown in Table 1.

Table 1.

Prices used in Valuating the Foodstuffs Consumed during the year ended 30th June, 1935.

	£	s.	d.
Chaff (Oaten or Wheaten) per ton	4	15	0
Clover Hay per ton	3	0	0
Silage per ton	0	7	0
Wheat (Crushed) per bushel	0	3	6
Oats (Crushed) per bushel	0	2	2
Barley (Crushed) per bushel	0	3	8
Bran per bushel	0	1	2½
Pollard per bushel	0	1	3½
Meggitts Meal per cwt.	0	13	6
Brewers' Grains per bushel	0	0	5
Oilcake per cwt.	0	9	6
Key Meal per cwt.	0	10	0
Green Lucerne per ton	1	0	0
Green Maize, Sudan Grass, and Cereal Crops—			
Chaffed, per ton	0	6	0
Grazed, per head per week	0	2	6
Pasture per head per week	0	1	6

Using the above figures, the average cost of feeding herds under test during the 1934-35 season has been calculated. It will be noted in Table 2 that the average production of milk and butter fat is slightly lower than in the preceding year, there being a decrease of 38 gallons of milk and 7 lbs. of butter fat per cow. This decrease probably is due to the exceptional season experienced. In general, however, the results of the last few years compare very favourably with those of earlier years. Contrary to expectation the cost of feed per head of stock is slightly lower than in 1933-34, which indicates that the owners of stud herds are endeavouring to keep the cost per unit production of milk and butter fat as low as possible, and even during such a disadvantageous season unit production costs are not greatly in excess of those of other years.

The following table gives the average cost of fodder since 1923-24, when the present scheme was initiated:—

TABLE 2.—PURE-BRED COWS UNDER OFFICIAL TEST.

Average Results for last Eleven Years.

Year ending 30th June:	Average Milk Yield per Cow.	Average Butter Fat per Cow.	Average Cost of Feed per Cow.	Average Feed Cost to Produce 1 lb. of Butter Fat.	Average Feed Cost to Produce 1 Gallon Milk.	Average Value of Butter Fat per lb.
	gals.	lbs.	£ s. d.	pence.	pence.	pence.
1924	600	319·50	10 4 10	7·7	4·09	19·5
1925	652	308·59	14 13 2	10·77	6·15	17·5
1926	624	312·01	14 14 7	11·15	5·66	19·0
1927	602	290·72	14 10 5	12·00	5·79	19·0
1928	592	280·56	15 11 4	13·34	6·34	19·5
1929	629	295·10	15 1 0	12·24	5·74	20·0
1930	636	294·98	14 10 3	12·74	5·10	19·5
1931	643	301·6	9 14 7	7·74	3·64	16·0
1932	696	318·96	10 18 3	8·21	3·76	14·0
1933	664	308·6	9 2 3	7·08	3·29	11·0
1934	720	333·7	10 2 6	7·28	3·37	10·0
1935	682	326·61	9 18 0	7·34	3·49	12·5

It is interesting to compare the results obtained from the three breeds under test. These are shown in the following table:—

TABLE 3.—BREEDS COMPARED AS PRODUCERS OF MILK AND BUTTER FAT.

Breed.	Average Yield of Milk per Cow during 9 months.	Average Test.	Average Yield of Butter Fat per Cow during 9 months.	Average Cost of Feed per Cow.	Cost of Food to Produce 1 gallon Milk.	Cost of Food to Produce 1lb. Butter Fat.
	lb.	%	lb.	£ s. d.	d.	d.
Jersey (14 herds) ...	5,968	5·28	314·87	8 17 6	3·57	6·77
Guernsey (6 herds) ...	6,628	5·02	333·28	9 12 0	3·41	6·91
A.I.S. (11 herds) ...	7,619	4·22	321·32	11 2 9	3·59	8·32

As in previous years the Jersey is the most economical in the production of butter fat. This, however, is offset by the lower average butter fat production of the Jersey, being 7 lbs. less than the Shorthorn and 19 lbs. less than the Guernsey. The Shorthorn shows the highest cost per pound of butter fat, but produces more milk than either of the two other breeds. When all aspects of the three breeds are considered, there is little to choose between them, and selection depends entirely on individual preference.

Table 4 gives an indication of the variation in cost of production between herds situated in the drier areas of the State and those in areas of heavier rainfall.

TABLE 4.—COST IN LIGHT RAINFALL AREAS COMPARED WITH HERDS IN THE SOUTH-WEST.

Average.	Production.		Cost of Feed for—	
	Milk.	Butter Fat.	1 Gallon Milk.	1lb. Butter Fat.
	lb.	lb.	d.	d.
Dry Areas (15 herds)	6,840	335·70	3·91	8·34
Wet Areas (16 herds)	6,793	321·76	3·14	6·63

The actual average production of milk and butter fat is higher in the drier areas than in the wetter areas, but the costs per unit of milk and butter fat are much higher in the drier areas. This is a very serious problem to the herd owner and indicates the great value of green fodder. In these areas the lactation period should commence early in autumn, preferably in April or May, so that the nine months' period may be complete by December.

In Table 5 the herds in order of merit as producers of butter fat are shown. The first place was gained by the herd at the Sabina Vale Stud Farm with an average production of 429.12 lb. of butter fat, showing a profit over feeding costs of £13 8s. with the value of butter fat at 12½d. The second and third places were gained respectively by Messrs. Robinson Bros., York, and Mr. W. G. Burges, Burges Siding.

TABLE 5.—HERDS IN ORDER OF MERIT AS PRODUCERS OF BUTTER FAT.

Place.	Herd.	Area—W, Wet; D, Dry.	Breed.	Average Production of Butter Fat per Cow during 9 months.	Available Skim Milk per Cow.	Value of Butter Fat at 12½d. per lb.	Value of Skim Milk at 1d. per gallon.	Gross Return from Fat and Skim Milk.	Cost of Feed per Cow during 9 months.	Profit per Cow by Sale of Butter Fat.	Cost of Feed to produce 1 lb. of Butter Fat.
				lb.	lb.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	d.
1	V	W	Jersey	429·12	4,788	22 7 0	1 19 11	24 6 11	8 9 0	13 8 0	4·74
2	CC	D	do.	408·60	4,526	21 5 7	1 17 11	23 3 6	11 0 0	10 5 7	7·08
3	D	D	A.I.S.	393·75	4,275	20 9 4	1 15 7	22 4 11	8 6 0	12 3 4	5·04
4	S	D	Guernsey	389·70	4,766	20 5 11	1 19 9	22 5 8	13 3 0	7 2 11	8·09
5	R	D	do.	379·19	5,399	19 15 0	2 5 0	22 0 0	12 5 0	7 10 0	7·75
6	X	W	do.	375·93	4,869	19 11 7	2 0 7	21 12 2	10 15 0	8 16 7	6·87
7	W	W	Jersey	367·25	4,124	19 2 7	1 14 4	20 16 11	12 14 0	6 8 7	8·37
8	BB	W	A.I.S.	353·79	6,004	18 8 6	2 10 9	20 19 3	14 19 0	3 9 6	10·09
9	AA	D	do.	344·61	6,252	17 19 0	2 12 1	20 11 1	13 13 0	4 6 0	9·49
10	P	W	Jersey	338·40	3,882	17 12 6	1 12 4	19 4 10	8 3 0	9 9 6	5·79
11	N	D	A.I.S.	330·57	5,983	17 4 4	2 9 10	19 13 4	12 9 0	4 15 4	9·09
12	DD	D	do.	327·51	4,869	17 1 2	2 0 7	19 1 9	15 7 0	1 14 2	11·25
13	FF	W	Guernsey	325·89	4,387	16 19 6	1 16 7	18 16 1	6 16 0	10 3 6	5·01
14	U	W	Jersey	323·08	3,718	16 16 6	1 11 0	18 7 6	8 17 0	7 19 6	6·56
15	C	W	A.I.S.	322·56	5,216	16 16 0	2 3 6	18 19 6	12 10 0	4 6 0	8·98
16	I	D	do.	321·39	5,656	16 14 9	2 7 2	19 1 11	9 7 0	7 7 9	7·03
17	E	W	Jersey	317·52	2,923	16 10 9	1 4 4	17 15 1	4 12 0	11 18 9	3·48
18	Y	D	do.	315·45	3,686	16 8 7	1 10 9	17 19 4	8 19 0	7 9 7	6·81
19	G	W	Guernsey	312·57	3,321	16 5 7	1 7 8	17 13 3	5 4 0	11 1 7	4·01
20	F	D	A.I.S.	310·32	5,218	16 3 3	2 3 6	18 6 9	12 6 0	3 17 3	9·53
21	Z	W	Jersey	304·83	2,938	15 17 6	1 4 6	17 2 0	5 19 0	9 18 6	4·68
22	J	D	do.	294·12	4,076	15 6 4	1 14 0	17 0 4	13 10 0	1 16 4	9·90
23	T	W	do.	294·03	3,621	15 6 3	1 10 2	16 16 5	7 19 0	7 7 0	6·51
24	K	D	Guernsey	292·86	3,853	15 5 0	1 12 1	16 17 1	9 0 0	6 5 0	7·32
25	L	W	A.I.S.	286·38	4,418	14 18 1	1 15 2	16 13 3	7 12 0	7 6 1	6·36
26	A	D	Jersey	283·14	3,080	14 14 11	1 5 8	16 0 7	12 9 0	2 5 11	10·56
27	O	D	do.	280·89	3,375	14 12 7	1 8 1	16 0 8	9 13 0	4 19 7	8·25
28	Q	W	do.	279·27	2,908	14 10 11	1 4 3	15 15 2	5 7 0	9 3 11	4·60
29	B	W	A.I.S.	275·49	3,965	14 7 0	1 13 0	16 0 0	10 13 0	3 14 0	9·30
30	H	W	do.	254·61	4,820	13 5 2	2 0 2	15 5 4	6 6 0	6 9 2	5·96
31	M	D	Jersey	225·00	2,255	11 14 4	0 18 9	12 13 1	7 15 0	3 19 4	8·29
Average	...	...	...	326·61	4,337	17 0 2	1 16 2	18 16 4	9 18 0	7 2 2	7·34

In Table 6 the herds have been listed in order of merit as producers of milk. Shorthorns are worthy of comment as the first six places were gained by herds of this breed. The leading herd was owned by Mr. E. T. Thatcher, of Byford. The second and third places were gained by Mr. P. E. Warburton, Bridgetown, and Mr. A. Della, Osborne Park, respectively.

TABLE 6.—HERDS IN ORDER OF MERIT AS PRODUCERS OF MILK.

Place.	Herd.	Breed.	Average Yield of Milk per Cow during 9 months.	Value of Whole Milk at 1s. per gallon.	Cost of Food per Cow during 9 months.	Profit per Cow over Cost of Feed during 9 months.	Cost of Food to produce 1 gallon Milk.
			lb.	£ s. d.	£ s. d.	£ s. d.	d.
1	AA	A.I.S.	8,835	44 3 6	13 13 0	30 10 6	3·70
2	BB	do.	8,771	43 17 1	14 19 0	28 18 1	4·06
3	N	do.	8,647	43 4 8	12 9 0	30 15 8	3·48
4	I	do.	8,284	41 8 4	9 7 0	32 1 4	2·72
5	C	do.	7,795	38 19 6	12 10 0	26 9 6	3·72
6	F	do.	7,795	38 19 6	12 6 0	26 13 6	3·79
7	X	Guernsey	7,410	37 1 0	10 15 0	26 6 0	3·48
8	DD	A.I.S.	7,410	37 1 0	15 7 0	21 14 0	4·97
9	H	do.	7,355	36 15 6	6 6 0	30 9 6	2·06
10	R	Guernsey	7,332	36 13 2	12 5 0	24 8 2	4·00
11	V	Jersey	7,320	36 12 0	8 9 0	28 3 0	2·78
12	S	Guernsey	7,295	36 9 6	13 3 0	23 6 6	4·32
13	CC	Jersey	7,029	35 2 11	11 0 0	24 2 11	4·12
14	L	A.I.S.	6,908	34 10 10	7 12 0	26 18 10	2·64
15	FF	Guernsey	6,874	34 7 5	6 16 0	27 11 5	2·39
16	D	A.I.S.	6,750	33 15 0	8 6 0	25 9 0	2·94
17	W	Jersey	6,626	33 2 7	12 14 0	20 8 7	4·64
18	J	do.	6,528	32 12 10	13 10 0	19 2 10	4·46
19	B	A.I.S.	6,405	32 0 6	10 13 0	21 7 6	3·99
20	P	Jersey	6,312	31 11 2	8 3 0	23 8 2	3·10
21	U	do.	6,131	30 13 1	8 17 0	21 16 1	3·46
22	Y	do.	6,095	30 9 6	8 19 0	21 10 6	3·52
23	T	do.	6,023	30 2 4	7 19 0	22 3 4	3·27
24	O	do.	5,751	28 15 1	9 13 0	19 2 1	4·01
25	G	Guernsey	5,689	28 8 11	5 4 0	23 4 11	2·20
26	Z	Jersey	5,486	27 8 7	5 19 0	21 9 7	2·60
27	A	do.	5,422	27 2 2	12 9 0	14 13 2	5·51
28	Q	do.	5,342	26 14 2	5 7 0	21 7 2	2·41
29	E	do.	5,247	26 4 8	4 12 0	21 12 8	2·10
30	K	Guernsey	5,170	25 17 0	9 0 0	16 17 0	4·15
31	M	Jersey	4,505	22 10 6	7 15 0	14 15 6	4·14
Average	...	... ...	6,819	34 1 11	9 18 0	24 3 11	3·49

TABLE 7.

Summary of Results 1934-35.

The average pure bred cow under Official Test produced in nine months—

(i) 6,819 lb. Milk.

(ii) 326.61 lb. Butter Fat.

	£ s. d.
(i) Value of Whole Milk at 1s. per gallon	34 1 11
Cost of Feed for 9 months	9 18 0
Net Return by Sale of Whole Milk	£24 3 11
(ii) Value of Butter Fat at 12½d. per lb.	17 0 2
Value of Skim Milk at 1d. per gallon	1 16 2
Gross Return	£18 16 4
Cost of Feed for 9 months	9 18 0
Net Return by Sale of Butter Fat and Use of Skim Milk	£8 18 4

REDWATER IN DAIRY COWS.

J. F. Filmer, B.V.Sc.,

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Redwater in cattle! Immediately one thinks of the North-West, and of ticks, and of the disease which they transmit to the cattle in that area. This is only natural, for by far the most common causes of redwater in Australia, and in the world, are the piroplasms—those small blood parasites which are carried by the cattle tick.

Recently, however, there has been brought to the notice of the Veterinary Branch a disease of dairy cows which is also known as redwater. This disease occurs in the Great Southern and South-West districts where cattle ticks are unknown. It appears to affect only cows, and generally only good milking cows which have had several calves. These are generally affected within a month or two after calving. The disease is seasonal and seems to occur only in the winter when there is an abundance of green feed. The feeding of crops, especially rape, appears to be a predisposing cause.

Generally the first symptom noticed is scouring, but this is soon followed by a colouration of the urine which may vary from light red to a dark brown or almost black. In the South-West the condition is sometimes called blackwater. The scouring is followed in one or two days by a very obstinate constipation, and about this time the milk yield falls rapidly and the appetite also decreases. The breathing, and especially the heart beat, may be very fast, up to three times the normal rates, but there does not appear to be any fever. The white of the eye is often a muddy yellow.

Sometimes very acute cases are encountered and in these death may take place in 24 hours. Usually, however, if the cow is treated correctly she recovers in about a week, but the milk yield does not return to normal until after the next calving. In some cases the end of the tail is said to fall off several months after recovery.

If the cow dies and is opened the following changes are noted in the organs. The liver is somewhat large, generally yellowish and appears fatty when cut. The gall badder may be much enlarged, containing up to a pint of bile. The spleen (or melt) is also rather large, and when cut appears very red and pulpy. The heart may show small blood spots on its surface. The fourth stomach and bowels are usually slightly inflamed and show reddish patches. The contents of the small bowels nearest to the stomach are stained yellow by bile.

Treatment should be directed towards curing the constipation. For this purpose the following should be administered as a drench:—

Epsom salts—1 to 1½ lbs.
Common salt—½ lb.
Nitre—1 ounce.
Treacle—½ lb.
Ground ginger—1 ounce.
Water (warm)—1 quart.

This should be repeated, if necessary, in 24 hours. The cow should be encouraged to drink but food is not important.

The origin of the red colour in the urine is interesting. In a district in South Australia and in other well defined areas, widely scattered over the world, cows suffer from a bladder complaint in which blood finds its way into the urine. But that is not the explanation in the disease under discussion. If blood is present and the urine is allowed to stand in a bottle, the blood will sink to the bottom, leaving normal coloured urine above it. But in this disease the colour is dissolved in the urine and does not fall to the bottom on standing. This colouring matter comes from destroyed red blood cells. Normally when blood cells are destroyed in the body (they live about three weeks) the colouring matter is taken to the liver and from there to the bone marrow where it is used for making fresh red cells. If, however, for any reason the red cells are destroyed in excessive numbers the body then has to cope with an unusually large amount of colouring matter. The bone marrow speeds up its operations and tries to turn out red cells as quickly as they are destroyed. It even turns them into the blood stream before they are quite finished, and in such diseases these immature red cells can often be seen in blood smears. But if the disease is at all acute the bone marrow cannot keep pace. The spleen and liver then do their best by breaking up the colouring matter, which is called haemoglobin, into bile and iron. The bile is given off through the gall bladder into the bowels, hence the enlarged gall bladder and bile stained bowel contents. Some of it may be absorbed into the blood stream and it then causes the jaundice which shows up as a yellow staining of the tissues, being most commonly noticed in the white of the eyes. The iron is stored for future use in the spleen and liver and kidneys, and can be readily seen there in suitably stained microscopic sections. Sometimes, however, even this process will not cope with all the colouring matter, and there is then nothing for the body to do but to get rid of the excess, which it does by pouring it out through the kidneys into the urine. Hence the redwater. This all means that the red cells are very greatly reduced in number. In one case instead of there being eight millions in a very small drop of blood there were only 1¾ millions. Now the function of the red cells is to carry oxygen from the lungs to all the various parts of the body, none of which can operate without it. When the red cells are reduced in number the heart beats faster so that they are circulated more frequently, but even then they cannot indefinitely do the work of a normal number of cells. In the tick fever form of redwater the red cells are destroyed by a pear-shaped microbe known as a piroplasm which enters the cell itself. In this disease, however, no such parasite can be detected. Reports from America indicate that a very similar disease there is cause by bacteria belonging to the same family as that which causes Braxy-like disease of sheep in Western Australia.

By the use of a vaccine prepared from these bacteria American veterinarians have been able to prevent the disease. It has not so far been possible to detect any such bacteria in Western Australian cases of redwater, but further search will be made as opportunities present themselves.

A small experimental vaccination of cows on three affected properties has been made this year, using the vaccine prepared by Dr. Bennetts for the prevention of Braxy-like disease in sheep. While it is possible that this will prove effective, the Veterinary Branch is very anxious to discover the bacteria which are causing the disease. It would greatly assist the work of investigation if farmers would notify the Chief Veterinary Surgeon by wire or telephone when cases of this disease occur.

THE PREVENTION OF SO-CALLED "RICKETS" IN LAMBS AND FOALS.

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Department of Agriculture.

For more than twenty years some difficulty has been experienced in breeding sheep, horses and cattle on limestone country, particularly in certain districts, in this State. The progeny of stock depastured continuously on such country become affected, as suckers, with a condition popularly known as "rickets." This name is an unfortunate one. The disease referred to is in no way related to zamia poisoning, which in this State frequently receives the same popular designation, and the name rickets or rachitis, should be applied only to a well-defined disease of young animals characterised by an abnormal development of the skeleton resulting in thickening of joints and softness of bone.

The manifestations of the so-called "rickets" in lambs, foals and calves differ considerably. Lambs are affected with a nervous disorder resulting in a characteristic inco-ordination of gait which has led to the scientific designation ataxia. Foals (and calves) are affected with a condition simulating true rickets.

Enzootic ataxia of lambs occurs in the Gingin and Dandarragan districts and on one property at Mt. Barker. It has been recognised recently at Yallingup, and there is some evidence that further coastal areas of the South-West, and even of the North-West, are similarly affected.*

The "rickets" in foals and calves is, so far as we are aware, confined to the Gingin and Dandarragan districts, and some coastal areas in the South-West.

An investigation of ataxia in lambs in these districts has led to the development of a treatment which is giving very promising results as regards the prevention of ataxia, and of "rickets" in foals. As it appears probable that these diseases do occur, and may become a source of economic loss, in areas outside those districts where investigations are being carried out, a brief description of the conditions and of the method of preventing them is warranted.

1. ENZOOTIC ATAXIA IN LAMBS.

A full description of the disease has been published previously, Bennetts (1). Enzootic ataxia affects lambs generally when from four weeks to four months old, but occasionally at birth or when a few days old. The incidence varies from less than 5 up to 100 per cent. It is more severe in the progeny of ewes which have been depastured continuously for more than one year on the affected country, the number of ataxic lambs becoming progressively greater each season. The incidence also increases with development and pasture improvement.

Symptoms.—When from 4-12 weeks old the lamb becomes unthrifty in appearance and growth is checked. It becomes anaemic and within a few days develops ataxia, viz., after driving for a short distance an inco-ordination of the hind legs is noted, the animal having no proper control over their movements. Finally the hind quarters sway sideways, and the lamb falls over. Rest is followed by temporary recovery but symptoms soon re-appear with further driving; the animal becomes greatly distressed and is rapidly fatigued. With time and loss of condition ataxia becomes progressively more manifest. Later the lamb can only progress for a few

* An apparently identical disease occurs in South Australia, and in other countries, notably Peru, Sweden and the British Isles.

yards without collapse of the hind limbs and is ultimately unable to stand. Death generally occurs within 3 or 4 weeks of symptoms being observed. This is the usual type of the disease and is almost always fatal.

Lambs 3-4 months old may show a more chronic non-fatal type characterised by ataxia, some loss of condition and a check in growth. These older animals are able to fend for themselves and may grow fairly well even if markedly affected. Frequently some improvement may occur and only a slight abnormality in gait persists but this is seldom entirely lost. On the other hand a much more acute form is sometimes seen, particularly in the late drop of ewes which have lambed for more than one season on an affected property. It affects very young lambs, which show a general muscular inco-ordination followed by unconsciousness and death within one to five days.

Post-mortem Appearances of Lambs Allowed to Die.—The body is in poor condition, generally emaciated. The skeleton is badly developed, the bones being light and brittle. Frequently there is a wasting of muscles of hind limbs. The only typical changes are microscopic—these consisting of a characteristic degeneration of nerve fibres in the spinal cord, which is apparently responsible for the inco-ordination of gait.

Cause.—This has not been determined. The disease is definitely confined to certain properties which, with one exception, are on limestone country. It is evidently due to factors which are present only in certain restricted areas. All available evidence points to a cumulative poison which is excreted in the milk of the ewes, thus exerting a toxic effect on the progeny. For reasons discussed in a recent publication, Bennetts (2) lead was suspected although not proved.

Prevention—

(i) *By suitable farm management.*—Stockowners in the affected area have found by practical experience that the incidence may be prevented to a marked degree by changing in-lamb ewes to a different class of country for a period of about eight weeks during the early part of the year. Shifting the flock, soon after lambing, to similar country is also effective in preventing or arresting the progress of the disease. An alternative practice is to buy breeding ewes from an outside district each November and mating them soon after purchase, when the progeny, in normal seasons, will not develop ataxia. If, however, green pasture is unusually early (March-April) or if the lambs are dropped late (July-August) the incidence of ataxia may be severe.

It has also been shown that lambs can be successfully reared on the milk of cows grazing on the affected area if taken away from their mothers in the early stages. Lambs which show the first symptoms only after reaching the age of about three months may be reared successfully if weaned on to the same pasture.

(ii) *By administration of Ammonium Chloride.*—Experiments were carried out during 1933 and 1934 at Gingin and Dandarragan to determine whether the administration of ammonium chloride, because of its known "deleading" properties, to in-lamb ewes would prevent the appearance of ataxia in the progeny.

These experiments, which are fully detailed in a publication referred to, Bennetts (2), demonstrated that the consumption of a lick containing 16 per cent. of ammonium chloride, at the rate of 4-5 ounces per week for some two months prior to lambing, prevents the disease appearing in the progeny later. The favourable influence on the general health and development of the lambs is remarkable. The beneficial effects could only be attributed to the ammonium chloride taken, for salt alone, which is the other constituent of the lick, has not the same effect.

The following table illustrates the results of one experiment carried out at Gingin:—

TABLE 1.

Group.	No. of Ewes in group.	No. of Lambs dropped.	No. of Lambs Surviving Nov. 3rd.	Live weight of Lambs, Nov. 3rd; average age 16 weeks.	No. affected with Ataxia.
No. 1.—Ammonium Chloride Lick	12	11	10	84 lbs. 76 ,, 70 ,, 71 ,, 61 ,, 60 ,, 63 ,, 59 ,, *a*49 ,, *b*29 ,,	3 affected 1 death
			Average ...	= 61·5-lbs.	
No. 2.—Controls (no lick)	9	11	3	53 lbs. 34 ,, 26 ,,	11 affected 8 deaths
			Average ...	= 37·7 lbs.	

a = ataxic lambs. *b* = lamb born Sept. 15—also ataxic.

Note.—The lambs were crossbreds, the progeny of ewes retained for a second season without change of country and they were designedly mated late so that lambing occurred during late July and August. Such conditions were known to be followed by a severe incidence of ataxia, 100 per cent. in an experimental flock under identical conditions but without treatment having become affected during the previous season.

The tabulated weights of the eight unaffected lambs in the lick group are a good indication of their healthy appearance and development, which compared more than favourably with that of similar types of lambs of the same age reared under the most favourable local conditions (*i.e.*, mothers having change of country prior to lambing). The control group calls for no comment.

A large scale field experiment was carried out on a property in the Dandaragan district* in 1934. Ammonium chloride lick was given to 459 aged ewes (the most susceptible group). Of 381 lambs marked from this group only 2.4 per cent. died from ataxia or other causes. In a similar line of aged ewes which did not receive the lick 15.5 per cent. of the 2,556 lambs marked died, the great majority as the result of ataxia. As expected the incidence was not so great in the progeny of younger ewes, but here again it was considerably higher than in the lick group —there being a 10 per cent. mortality in 2,813 lambs.

As in the Gingin experiment, the progeny of the lick group were outstanding, being healthier in appearance and better grown than those in any neighbouring flocks. An unusually early season, with green pasture in March, was apparently responsible for the unusually high incidence of ataxia on this property during 1934.

* The incidence of the disease is not generally severe on this property, a newly developed one, and the practice of giving ewes a change of country has been discontinued since 1932.

No properly controlled experiments have been carried out, as yet, to determine the effect of ammonium chloride administered by other methods.

The lick is being used on a much larger scale at both Gingin and Dandarragan during the present season and the results will be reported at a later date.

2.—SO-CALLED "RICKETS" IN FOALS.

In the Gingin and Dandarragan districts this appears to be characterised by unthriftiness, depressed growth rate and in the more severe cases by pronounced stiffness of the limbs which may also bend at the joints. The bones themselves do not bend as in rachitis, but enlargements of joints may eventually develop ("apple joints.") Affected animals frequently stand upon the toes, apparently as a result of contraction of tendons. The condition may be apparent at birth or may develop within the succeeding six months. It does not develop after weaning although foals tend to remain unthrifty and poorly grown until two years old, even when depastured on excellent permanent pasture consisting of a well balanced mixture of clovers and grasses, together with supplementary feeding with concentrates.

Opportunities for clinical examination have been few and the pathology has not been fully studied, therefore for the present it is referred to by the popular term "rickets." The etiology is unknown although it seems probable that the same underlying causes are responsible for these diseases of foals and lambs in certain definite areas of the State.

Prevention and Treatment.

(i) *By Suitable Farm Management.*—Stockowners have found by practical experience that stable feeding of brood mares, even with grain and chaff grown on the same property, will prevent the foal disease. When foals commence to "go wrong" exclusive stable feeding of the mother arrests the progress of the disease and recovery follows. The tendency to unthriftiness and slow growth rate, however, persist. If mother and foal are changed to "sound" country complete recovery is rapid even where there are indications that marked bone changes exist.

(ii) *By Administration of Ammonium Chloride.*—A stockowner who breeds horses and who is familiar with our experiments in the prevention of ataxia in lambs expressed a desire to try the effect of ammonium chloride on foals. He was advised to administer ammonium chloride to the mothers in drinking water in the proportion of 1 ounce to 6 gallons, although, in view of the different symptoms exhibited by lambs and by foals, the treatment was not considered hopeful. He found, however, that mares readily took ammonium chloride when mixed with molasses and water and sprinkled in their feed—two ounces daily being given in this manner.

The results obtained were most striking, the ammonium chloride being apparently effective in both preventing and curing "rickets" in foals. The beneficial effect on the general health and growth rate of the young was astounding, more particularly as there were definite indications that the unusually early 1934 season was unfavourable to the rearing of foals as well as of lambs. Previous experience had shown the impossibility of rearing thrifty well grown foals on the property, despite the apparently ideal pasture conditions referred to, and supplementary feeding, growth having been definitely retarded until about twelve months old.

From the end of May, 1934, five mares with foals (1933 foaling), received ammonium chloride in water (one ounce to six gallons) for a period of three months, the average consumption being about one ounce daily. These foals, which

were seven months old at the commencement of the experiment, were very unthrifty and poorly grown. Two months after treatment they commenced to thrive and all developed into perfectly healthy well grown yearlings.

A thoroughbred yearling which, when inspected in April, 1934, was unthrifty and under developed received ammonium chloride at the rate of six ounces per week in the feed from May to September of that year. It is now a perfectly healthy animal as well grown as New Zealand two-year olds with which it is depastured.

The results obtained with five foals born in 1934 are even more surprising. Their mothers received the following treatment:—

Mare No. 1—Ammonium chloride 2 ounces per day in feed for 6 weeks before parturition.

Mare No. 2—Ammonium chloride 2 ounces per day in feed for 4 weeks before parturition.

Mare No. 3} Ammonium chloride 2 ounces per day in feed for 1
Mare No. 4} week before parturition.

Mare No. 5—Ammonium chloride—Nil before parturition.

For three weeks after foaling all received the same treatment with ammonium chloride in the feed. The progeny of Nos. 1 and 2 developed normally. The progeny of No. 3 was born with bent forelegs and was unthrifty. The progeny of No. 4 within a week of birth became unthrifty and developed weakness in the hock joints. The progeny of No. 5 was born with enlarged joints and was unthrifty. The progeny of Nos. 3-5 apparently did not respond to treatment but it was found that their mothers were not receiving their quota of ammonium chloride owing to carelessness on the part of the attendant. The owner of the property attended to them personally some weeks later and saw that they received the two ounces daily. The foals, even the one with bent legs, had completely recovered ten days later and the treatment was discontinued at 14 days. When inspected on 12th April, 1935, they were perfectly healthy in appearance and very well grown.

In May, following the advent of green feed a month earlier, foal No. 3 at the age of seven months once more developed the leg abnormality referred to above. On June 1st this foal was weaned and was given one ounce per day of ammonium chloride in the feed. Recovery was practically complete three weeks later. The other foals, although apparently normal, were treated similarly and remained healthy.

A further experiment being carried out by the owner of the same property appears to indicate that the health and condition of resting horses is greatly improved, during the green period, by the daily administration of ammonium chloride in supplementary dry feed. These observations are being continued.

3.—CONCLUSIONS.

(i) Although the definite causes of enzootic ataxia in lambs and of "rickets" in foals have not been determined there is some evidence that both conditions are closely related. As published elsewhere, it has been postulated that the former is a manifestation of lead poisoning.

(ii) Preventive treatment based on this assumption has given very promising results in both diseases. The consumption, by ewes, of a lick containing 16 per cent of ammonium chloride, at the rate of 4-5 ounces per week for a period of 9-10

weeks during the late stages of pregnancy prevented the development of ataxia in the progeny. The favourable influence on the health and development of the lambs was remarkable.

(iii) There is evidence also that ammonium chloride, suitably administered, will prevent and cure (at least in the early stages) "rickets" in foals. It is recommended that, as a prophylactic measure, brood mares receive 2 ounces of this salt for a period of from 3-4 weeks before to at least 3 weeks after foaling.

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GLYCERO-BORIC BLOWFLY DRESSING.

NOTES RECEIVED FROM COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

The work of the Council for Scientific and Industrial Research on the blowfly problem has been mainly directed towards the discovery of means of preventing the attack on sheep by blowflies, but the problem of cleaning up blowfly strikes when they occur has also received considerable attention. Numerous dressings commonly used by pastoralists, and also many other substances, have been tested by the Council's Division of Economic Entomology at Canberra, but, until a few months ago, no dressing was found to have all the desirable properties.

To be satisfactory a blowfly dressing must not only kill the maggots present, but must also help to heal the wound, and render it no longer attractive to blowflies. Most dressings commonly used kill the maggots, but many of them also injure the delicate skin of the sheep, and this has been shown to increase the susceptibility of the treated area to blowfly strike. The few dressings commonly used which do not damage the sheep's skin have been found to be unsatisfactory for other reasons.

When investigating the effect of various chemicals on the attractiveness of baits, Mr. M. R. Freney, the biochemist of the Council's team of blowfly research workers, found that baits treated with glycerine or boric acid did not attract blowflies. For various reasons it was thought that a combination of these substances might form a satisfactory blowfly dressing. Dr. I. M. Mackerras, Dr. M. J. Mackerras and Mr. Freney then carried out over a hundred tests with this dressing under rigorous conditions in the insectaries at Canberra, with most promising results.

This new dressing is a colourless, odourless, rather viscous fluid which is easily rubbed into the shorn area of a strike, and adheres readily to the fleece and skin. A few minutes after application the unpleasant normal odour of the strike is changed and becomes much less unpleasant. The maggots are killed rather slowly, twenty-four to thirty hours often elapsing before all are dead, but they cease to worry the sheep immediately the dressing is applied. Temperature records of struck sheep clearly show the relief afforded, the fever temperature (106deg. to 108deg. F.) quickly falling to normal (102deg. F.) after application of the dressing. The effect of the dressing on the strike wound is decidedly beneficial. The

extension of damage to the skin is immediately arrested, and inflamed but unbroken skin becomes soft, flexible and healthy, without any sign of crust. So far it has been found impossible to produce an experimental re-strike on a dressed area, even after liberal wetting, but the testing of this point is not yet completed.

In many respects the tests already carried out in insectaries are more rigorous than field tests; but the proof of the value of the dressing must ultimately depend upon the results of extensive tests under normal station conditions. Because of the promising results already obtained, however, the Council has decided to make the new dressing known to pastoralists at this stage, although final proof of its satisfactory large-scale applicability has not yet been obtained.

A relatively simple dressing, which has given quite good results, may be prepared as follows:—Take one gallon (13 lbs.) of glycerine, and add 3 lbs. of powdered boric acid (commonly known as boracic acid). A thick paste is formed which is then heated and stirred until all the boric acid is dissolved. This results in the formation of various borates of glycerine. After cooling, the clear solution should be kept in well corked bottles or tins, and should be used without dilution.

Better dressings may be made by using more elaborate methods of preparation. For example, preparations containing a higher proportion of boric acid and which have been subjected to temperatures of about 300deg. F. have given excellent results, but these would be difficult to prepare on a station. If the tests in progress ultimately prove these preparations to be decidedly better than the simple dressing described above, then a means of producing them in bulk at a reasonable price will no doubt be found.

At present prices of the pure chemicals, the cost of the dressing is 11s. per gallon, which works out at about 2d. for each sheep dressed. Tests are being made with crude glycerine, and if it should prove that this can be substituted for the pure product, costs will be about halved.

It is hoped that some pastoralists will try the glycero-boric dressing during the coming season, and that they will let the Council know what kind of results they obtain. Communications should be addressed to the Division of Economic Entomology, P.O. Box 109, Canberra City, F.C.T.

FIELD EXPERIMENTS WITH TOBACCO IN THE MANJIMUP-PEMBERTON DISTRICT.

A. Sharp, U.D.A., Agricultural Adviser.

The problems of what constitutes the best fertiliser for the tobacco crop, and what is the most suitable variety to grow, are of major interest to the Western Australian tobacco grower.

With regard to the former, the standard tobacco fertiliser in general use in Western Australia appears to have been evolved as a result of experience gained outside the State, and it was felt that definite information, obtainable only from properly controlled field tests, is required on the following points:—

(a) Is it advantageous to replace all or portion of the inorganic nitrogen in the standard tobacco fertiliser with organic nitrogen?

(b) In view of an apparent advantage reported to have been obtained in parts of U.S.A. and elsewhere from the use of fish manure, is the organic nitrogen as supplied in fish manure of special advantage for tobacco under our conditions as compared with other organic forms, such as blood or stable manure?

(c) What quantity of sulphate of potash should be included in the tobacco fertiliser for best results, particularly with regard to the burning quality of the leaf?

(d) What quantity of superphosphate should be included in the tobacco fertiliser for best results?

With regard to varieties, some experimental work was done at Manjimup under the direction of Mr. A. R. C. Clifton, Irrigation Officer, some years ago, as a result of which the variety "Hickory Pryor" was found to be very suitable. Since then, however, some other varieties have given promising results elsewhere, and it was felt that field tests should be carried out to determine their suitability as compared with "Hickory Pryor" under the conditions obtaining at Manjimup.

With the object of obtaining information on these matters, a series of experiments was planned in September, 1934, and arrangements were made with a number of growers to plant experimental plots on their properties in co-operation with the Department of Agriculture.

The following growers made available facilities for carrying out two experiments each on their farms:—

Messrs. W. Finch, Manjimup; W. Henwood, Donnelly River; D. Pitcher, Pemberton; A. Carter, Pemberton; and A. Palfrey, Pemberton; and the following, one experiment each:—Messrs. G. F. Combs, Jardee; Boyanich Bros., Jardee; G. Fontanini, Manjimup; J. Crawley, Jardee; P. Rumenos, Jardee, and N. Milentis, Jardee.

The writer here wishes to place on regord his very great appreciation of the whole-hearted manner in which these growers co-operated with him in bringing these experiments to a successful conclusion. The extra trouble involved in keeping the leaf from the various plots separate during harvesting, curing, and, in some cases, grading, was cheerfully undertaken, the growers concerned fully realising the value of such experimental work to the industry.

The general plan of the experiments was the same in all cases. The plots receiving the different treatments were planted in sequence, and repeated in triplicate. One treatment was utilised as a "control" with which the yields of the other plots were compared and calculated as a percentage of the control plot. A control was placed at the beginning and at the end of each series of plots. The sketch hereunder shows the general arrangement followed.

Plot 1.—Control.
Plot 2.—Treatment A.
Plot 3.—Treatment B.
Plot 4.—Treatment C.
Plot 5.—Control.
Plot 6.—Treatment A.
Plot 7.—Treatment B.
Plot 8.—Treatment C.
Plot 9.—Control.
Plot 10.—Treatment A.
Plot 11.—Treatment B.
Plot 12.—Treatment C.
Plot 13.—Control.

Owing to the ravages of Downy Mildew (so-called "Blue Mould") in the seed beds, some difficulty was experienced in obtaining an adequate supply of seedlings for some of the plots; some growers, in fact, were unable to complete transplanting operations until the end of November owing to the shortage. The exceptionally moist, cool weather which was experienced until the beginning of January provided almost ideal conditions for the spread of this disease, with the result that not only did it destroy many of the seed beds, but did considerable damage in the field, attacking plants which appeared to be quite healthy when set out. From January onwards, however, warm dry conditions prevailed, which resulted in checking the disease and permitting the plots to make good growth.

EXPERIMENT No. 1.

This experiment was designed to determine whether nitrogen in an organic form is more suitable for tobacco than in the inorganic form as supplied in the Standard tobacco fertiliser. The composition of 1,000 lbs. of the latter is:—

Sulphate of ammonia, ..	120 lbs.	supplying 33 lbs. nitrogen.
Nitrate of soda	60 lbs.	
Superphosphate	700 lbs.,	supplying 150 lbs. phosphoric acid.
Sulphate of potash ..	120 lbs.,	supplying 57 lbs. potash.

The experiment consisted of four plots, each of which received the same amount of plant food, being the equivalent of that supplied by 1,000 lbs. per acre of Standard tobacco fertiliser. On plots 2, 3 and 4 the nitrogen was supplied in the form of fish manure, dried blood, and stable manure, respectively. In each case the amount of plant food supplied was kept constant by making adjustments in the amounts of the other constituents where necessary.

The fertiliser mixtures used per acre were:—

Plot 1.—Control. Standard tobacco fertiliser, 1,000 lbs.

Plot 2.—Fish manure .. .. .. 720 lbs.
Superphosphate .. .. 320 lbs.
Sulphate of potash .. .. 120 lbs.

Plot 3.—Dried blood .. .. .. 300 lbs.
Superphosphate .. .. 700 lbs.
Sulphate of potash .. .. 120 lbs.

Plot 4.—Stable manure, 2,400 lbs. to 8,500 lbs., according to nitrogen content of sample used.
Superphosphate .. .. 700 lbs.
Sulphate of potash .. .. 120 lbs.

The experiment was carried out on the plantations of Messrs. W. Henwood, Donnelly River; Boyanich Bros., Jardee; D. Pitcher, Pemberton; G. Combs, Jardee. and A. Carter, Pemberton. All the plots were planted out during November. In every case, the control plots came away most rapidly, the plots receiving fish manure and dried blood rather more slowly, and the plots receiving stable manure lagged well behind. From the middle of January onwards, however, when really warm weather conditions were experienced, all the plots which received organic nitrogen made rapid progress, and in the case of the fish manure and dried blood, caught up with the control plants.

The average of the yields of cured leaf from the five plantations on which the experiment was carried out was as follows:—

	Lbs. per acre.	Percentage Yield.
Plot 1 (Control)	729	100
Plot 2 (Fish manure) ..	760	104
Plot 3 (Dried blood) ..	778	107
Plot 4 (Stable manure) ..	805	110

It will be seen, therefore, that all the forms of organic nitrogenous fertiliser used gave an increase in yield as compared with the inorganic form used in the standard fertiliser. The relatively high yields from the plots receiving stable manure came rather as a surprise in view of the slow growth in the early part of the season, and their somewhat backward appearance right up to harvesting. In one case, where the stable manure used had been conserved under cover, and contained a relatively higher percentage of nitrogen, and possibly more soluble nitrogen, than those samples kept in the open, the yield of the leaf exceeded that of the control plot by 48 per cent. This result demonstrated very strikingly the great value of properly conserved farmyard manure, all the more so when it is noted that this result was obtained from a dressing of only 2,400 lbs., or a little more than one ton, per acre, and without the addition of any artificial nitrogenous fertiliser whatever.

It was also noticeable that when the plants were approaching maturity, the leaf on the plots treated with organic nitrogen tended to ripen more evenly than that on the control plots, and, possibly as a result of this tendency, a definitely higher proportion of the former was graded as bright leaf. In view of the supreme importance of producing a high-grade leaf, this point is probably of even more importance than the increase in total yield.

While it is somewhat risky to draw definite conclusions from the results of a single season's work, it would appear that organic fertilisers give results definitely superior to those given by inorganic fertilisers, both as regards yield and quality of leaf. In view, however, of the fact that growth of the plants on the plots treated with organic nitrogen was very slow in the early stages, it is believed that still better results would be obtained if a proportion of the nitrogen were supplied in the form of nitrate of soda, which is immediately available as plant food, to give the young seedlings a good start, after which the slower acting organic fertiliser would be available to carry them along to maturity.

The following three fertiliser mixtures are suggested as being likely to give good results, and it is proposed to try out these on an experimental scale next season:—

1.	Nitrate of soda	60 lbs. per acre.
	Fish manure	530 lbs. „
	Superphosphate	410 lbs. „
	Sulphate of potash	120 lbs. „
2.	Nitrate of soda	60 lbs. per acre.
	Blood and bone	400 lbs. „
	Superphosphate	500 lbs. „
	Sulphate of potash	120 lbs. „
3.	Stable manure up to 5 tons per acre according to quality.	
	Nitrate of soda	60 lbs. „
	Superphosphate	700 lbs. „
	Sulphate of potash	120 lbs. „

Each of these mixtures will give approximately the same amounts of plant food constituents as 1,000 lbs. per acre of the standard tobacco fertiliser.

EXPERIMENT NO. 2

This experiment was designed to determine the effect of increasing the amount of potash in the fertiliser, particularly with regard to the burning quality of the leaf.

The experiment constisted of three plots, the first, or control, plot being fertilised with the Standard tobacco fertiliser. The second and third plots received the same amounts of nitrate of soda, sulphate of ammonia, and superphosphate as the control, but in the case of plot 2, the quantity of sulphate of potash was doubled, and in plot 3 it was trebled.

The following tables gives the actual mixtures used (lbs. per acre):—

	Plot 1. (Control.)	Plot 2.	Plot 3.
Nitrate of soda	60	60	60
Sulphate of ammonia	120	120	120
Superphosphate	700	700	700
Sulphate of potash	120	240	360

The experiment was carried out on the plantations of Messrs. W. Finch, Manjimup; A. Palfrey, Pemberton; W. Henwood, Donnelly, and D. Pitcher, Pemberton.

All the plots were planted out during November.

In every case, it was impossible to see any difference whatever between the plots during growth.

The average of the yields of cured leaf from the respective plots was as follows:—

Plot 1 (Control)	863 lbs. per acre.
Plot 2	858 lbs. „
Plot 3	836 lbs. „

These slight differences in yield cannot be regarded as significant.

There was no apparent difference in the quality of the leaf from the different plots when cured.

The increased application of potash, therefore, was of no benefit so far as yield of leaf was concerned. The effect on burning quality has not yet been determined, but samples of the leaf from the plots have been sent to the Tobacco Investigation Committee at Canberra to undergo smoking tests.

EXPERIMENT No. 3.

This experiment was designed to determine the effect of different rates of application of superphosphate on the yield of tobacco leaf.

The experiment consisted of three plots, the first, or control, plot being fertilised with Standard tobacco fertiliser. The second and third plots received the same dressing of nitrate of soda, sulphate of ammonia and sulphate of potash as the control, but in the case of Plot 2, the amount of superphosphate was reduced by 25 per cent., and in Plot 3, by 50 per cent.

The actual mixtures used were as follows (in lbs. per acre):—

	Plot 1. (Control.)	Plot 2.	Plot 3.
Nitrate of soda	60	60	60
Sulphate of ammonia	120	120	120
Superphosphate	700	520	350
Sulphate of potash	120	120	120

Theoretically, the application of superphosphate at the rate of 700 lbs. per acre is far too high, as the analysis of the tobacco plant would appear to indicate that it draws from the soil only a small fraction of the phosphoric acid contained in this amount of super.

The experiment was carried out on the plantations of Messrs. A. Carter, Pemberton; P. Rumenos, Jardee, and N. Milentis, Jardee. Planting out took place during the first half of November.

For about two months after planting out, little or no difference could be observed between the plots. When approaching maturity, however, the leaf on plot 3 appeared to be rather smaller and of less body than that on the control plots. Owing to pressure of work and shortage of labour and shed space during harvesting, the leaf from the different plots was not kept separate on two of the plantations, so that actual yields were not obtainable. On the other plantation, the yields of cured leaf were as follows:—

Plot 1 (Control)	767 lbs.	per acre.
Plot 2	793 lbs.	„
Plot 3	760 lbs.	„

These results show no significant reduction of yield as the result of applying reduced quantities of superphosphate.

The results of this experiment must, therefore, be regarded as inconclusive.

EXPERIMENT No. 4.

This was a variety Trial designed to determine whether any of the varieties "Gold Leaf," "Yellow Pryor," "Long Leaf Gooch," "Improved Mammoth," and "Cash" were likely to prove superior in yield and quality to "Hickory Pryor," which is the variety most favoured by growers at present for the Eastern States market.

The experiment was carried out on the plantations of Messrs. W. Finch, Manjimup; A. Palfrey, Pemberton; G. Fontanini, Manjimup, and J. Crawley, Jardee. All the plots were treated with Standard tobacco fertiliser.

During growth, all the varieties except "Improved Mammoth" closely resembled "Hickory Pryor" in general appearance, and matured at the same time as that variety. "Improved Mammoth" matured about two weeks later and carried rather larger leaves than "Hickory Pryor."

The average of the yields of cured leaf per acre from the respective plots was as follows:—

	Yield per acre.	Percentage yield.
Hickory Pryor	1,064 lbs.	100
Gold Leaf	956 lbs.	89
Yellow Pryor	1,383 lbs.	130
Long Leaf Gooch	1,192 lbs.	112
Improved Mammoth	922 lbs.	86
Cash	1,137 lbs.	107

"Improved Mammoth" proved to be the lowest yielder, and gave the poorest quality leaf on being cured.

"Yellow Pryor" gave the highest yield, and the quality of leaf was similar to that of "Hickory Pryor."

"Cash" also yielded well, being ahead of "Hickory Pryor" in this respect, and gave the best quality leaf of any of the varieties. Mr. Munster, of the British Australasian Tobacco Co., to whom samples of leaf of all the varieties were submitted, commented very favourably on this variety.

"Gold Leaf" and "Long Leaf Gooch" on the whole showed no particular superiority to "Hickory Pryor."

As the question of quality is of the utmost importance in the tobacco growing industry, representative samples of leaf from the experimental plots were collected and forwarded to the Tobacco Investigations Committee at Canberra in order to obtain a detailed report on the smoking quality, and a preliminary report on the smoking tests of the leaf samples has now been received.

In Experiment No. 1 none of the leaf from the plots receiving organic nitrogen was superior to that from the control plots. There was little difference between the leaf from the different organic nitrogen plots, that grown with dried blood being, if anything, the best.

In Experiment No. 2 the leaf from the plots receiving the smaller amounts of potash was the best. When the application of sulphate of potash exceeded 240 lbs. per acre, the quality of the leaf fell off.

In Experiment No. 3 the different applications of superphosphate gave no appreciable difference in the smoking quality of the leaf.

In Experiment No. 4 there was little difference between the varieties, "Hickory Pryor," "Cash," and "Gold Leaf" being probably best.

The report stresses the fact that these results are not to be regarded as final, as, after the leaf has undergone a period of ageing, the smoking tests may yield different results.

FRUIT INDUSTRY.

GEO. W. WICKENS,

Superintendent of Horticulture.

AREA AND PRODUCTION.

The outstanding feature in the fruit industry during the last ten years has been the steady and regular increase in the area devoted to apple production. In season 1923-24 there were 9,672 acres, and in season 1933-34 the total reached 12,297, an increase of 2,525 acres. The figures for 1934-35 are not yet available, but that season should register a further increase, while the fact that the importation of young apple trees during the year ended June, 1935, amounts to 25,339—enough to plant out 250 acres—shows no evidence of diminution in the rate of planting, and apples now represent nearly 60 per cent. of the total area under orchards in the State. Production annually approximates 1,000,000 bushels, and with 3,832 acres still to come into bearing Western Australian apple growers are vitally interested in having as little restriction as possible placed on the quantity shipped to markets overseas.

Pears vary little from year to year, either in acreage or production, the area being a little over 1,000 acres and the annual production approximating 100,000 bushels.

Oranges, which rank next to apples in area, reached their peak in season 1926-27 with 3,070 acres, dropping to 2,856 in 1929-30, are again on the up-grade, the figures for 1933-34 being 2,970 acres. The annual production approximates 250,000 bushels, and although this quantity appears small for a population of 450,000 people each season now sees low prices and difficult sales for navels in the months of June and July, and the problems of increasing local consumption and finding profitable overseas markets still remain to be solved.

The area under lemons has remained fairly constant at about 500 acres for a number of years, and the production of 60,000 cases annually should not unduly tax the consumptive capacity of Western Australia's population, but all the same there are definite gluts in the winter months.

Stone fruits—peaches, plums, apricots and nectarines—which are grown in this State almost entirely for selling as fresh fruit in the local market, show little variation from year to year, and in seasons when fruit fly is not present in abnormal numbers, production and demand are fairly even.

Grape-growing, providing fresh and dried fruit for local and overseas markets and wine-making, is one of the important items in Western Australia's fruit industry, and this year's (1935) currant production, with 2,095 tons, constituted a record for the State.

Full particulars of acreage and production of all fruits for season 1933-34 (latest figures available) are as follow:—

ACREAGE AND PRODUCTION OF FRUIT—SEASON 1933-34.

Orchards.

Kind of Fruit.	Area. Unproductive. acres.	Area. Productive. acres.	Area. Total. acres.	Production.
Almonds	57	184	241	93,194 lbs.
Apricots	106	572	678	50,553 bushels.
Apples	3,832	8,465	12,297	990,049 „
Bananas and Plantains ...	54	22	76	12,408 bunches.
Figs	55	300	355	37,528 bushels.
Lemons	61	434	495	58,162 „
Mandarins	32	138	170	13,265 „
Oranges	450	2,520	2,970	275,716 „
Other Citrus Fruits ...	16	21	37	2,120 „
Nectarines	57	146	203	14,013 „
Peaches	184	598	782	53,320 „
Pears	112	909	1,021	94,500 „
Plums	242	743	985	67,307 „
Quinces	14	70	84	7,997 „
Small Fruits	...	180	180	—
All other Fruits	59	127	186	—
Total	5,331	15,429	20,760	

Vineyards.

	Area.	Production.
Table Grapes	1,009 acres	52,032 cwt.
Wine Grapes	1,495 „	40,012 „
Drying Grapes	2,390 „	145,386 „
Not-bearing Vines	806 „	...
Total	5,700 „	237,430 „

Wine made from 1933-34 Season's Grape Crop.

Distillation Wine ...	169,725 gals.
Dry Wine	127,619 „
Sweet Wine	130,114 „
	427,458 „

Dried Fruit produced from 1933-34 Season's Grape Crop.

Raisins.				
Table Clusters.	Lexias.	Sultanas.	Currants.	Total.
389 cwt.	4,882 cwt.	6,621 cwt.	26,461 cwt.	38,353 cwt.

EXPORTS.

This year's export of fresh fruits constituted a record for Western Australia, the total reaching just a little short of 1,000,000 cases. The major portion, 859,463, comprised apples, and it is pleasing to record that prices realised on the markets in the United Kingdom were much better than those of last year. This was due to two causes—better fruit, and markets not over-supplied. In the former there is no doubt that raising the standards under the Commerce Regulations had a very beneficial effect, and though there was considerable heartburning in the early part of the season, at the close growers, shippers and departmental officers were convinced the innovation had been justified. 598,029 cases of apples were shipped to the United Kingdom, 181,544 to the continent of Europe, and the balance was distributed to various other parts of the world.

Grapes, with 57,482 cases, also constituted a record, Colombo taking the most—28,022—and Singapore next with 14,969. Growers report that on the whole prices for the season have been satisfactory.

Pears, with an export of 30,060, are under the usual quantity, and prices were not as good as last year. I have not seen many actual returns, but several growers advise that averaging good and poor prices the net return per case on local railway siding only works out at about 4s.

The orange export for the year—3,523 cases—when compared with production is only a negligible quantity, and can have no effect on local prices.

Full particulars, showing quantities of all fruit shipped and destinations are as follow:—

EXPORT OF FRESH FRUIT FROM WESTERN AUSTRALIA TO OVERSEAS PORTS FOR YEAR ENDING 30TH JUNE, 1935.

Destination.	Apples.	Oranges.	Pears.	Grapes.	Plums.	Nectarines.	Peaches.	Cherries.	Grape Fruit.	Lemons.	Passion Fruit Pulp.	Passion Fruit.	Quinces.	Totals.
	cases.	cases.	cases.	cases.	cases.	cases.	cases.	cases.	cases.	cases.	cases.	cases.	cases.	cases.
Port Swettenham ...	4	4	2¼	4	¾	...	...	1	...	...	...	1	...	17
Rangoon	12	...	19¾	777	...	...	...	...	...	...	...	...	...	808½
Batavia	5,243	387	95½	2,760	66½	...	6	...	...	...	...	...	...	8,558½
Singapore	27,057	1,299	325	14,969	237½	...	21¾	2	...	86½	...	...	...	44,897½
Sourabaya	1,438	25	31½	648	17½	...	...	...	...	...	...	...	...	2,159½
Saigon	300	...	...	...	...	...	...	...	...	...	...	...	...	300
Penang	918	15	1½	778	10	...	...	...	...	...	...	...	...	1,722½
Samarang	2,719	40	52½	1,288	24½	...	...	...	...	8½	...	...	...	4,132½
Belewan	...	...	...	30	...	...	...	...	...	...	...	...	...	30
London	422,939	243	25,816½	5,835	...	...	...	...	...	...	8	3½	18	454,863
Avonmouth	9,504	...	...	...	...	...	...	...	...	...	...	...	...	9,504
Manchester	3,845	...	...	...	...	...	...	...	...	...	...	...	...	3,845
Liverpool	77,739	...	935¼	200	...	...	...	...	...	...	...	...	...	78,874¼
Glasgow	60,390	...	...	96	...	...	...	...	...	...	...	...	...	60,486
Hull	12,325	...	...	...	...	...	...	...	...	...	...	...	...	12,325
Southampton	11,287	...	...	...	...	...	...	...	...	...	...	...	...	11,287
Hamburg	84,721	...	489	484	...	...	...	...	...	...	...	...	...	85,694
Stockholm	68,794	...	1,960¾	539	...	...	...	...	...	...	...	...	...	71,293¾
Antwerp	11,502	...	...	...	...	...	...	...	...	...	...	...	...	11,502
Rotterdam	16,527	...	...	...	...	...	...	...	...	...	...	...	...	16,527
Durban	745	...	...	...	...	...	...	...	...	...	...	...	...	745
Aden	450	...	...	50	...	...	...	...	...	...	...	...	...	500
Bombay	1,210	120	...	477	...	...	...	...	...	...	...	...	...	1,807
Mauritius	260	155	...	...	...	...	...	...	2	126	...	...	...	543
Calcutta	320	5	...	...	...	...	...	...	...	3	...	...	...	328
Haifa	300	...	...	...	...	...	...	...	...	...	...	...	...	300
Malta	250	...	...	...	...	...	...	...	...	...	...	...	...	250
Oslo	205	...	...	...	...	...	...	...	...	...	...	...	...	205
Jaffa	700	...	...	...	...	...	...	...	...	...	...	...	...	700
Colombo	7,732	959	37¾	28,022	64½	6	17	7	...	10	...	...	...	36,855¼
Port Said	29,127	271	293½	525	...	...	...	...	...	...	...	...	...	30,216½
Totals	859,463	3,523	30,060½	57,482	421	6	44¾	10	2	234	8	4½	18	
Grand Total ...	...	...	...	...	...	...	...	...	...	...	...	...	...	951,270¼

FRESH FRUIT IMPORTS.

Bananas are easily first in importance in quantity, those from overseas landed at Fremantle amounting to 30,216 cases, while the Eastern States sent 5,528 crates through Fremantle, 4,866 to Kalgoorlie and 49 to Albany. With the plantations at Carnarvon rapidly coming into production the importation should considerably diminish in the next few years.

One item on the import list is interesting in its smallness. I refer to lemons, which formed the subject of a deputation to the Hon. Minister some time ago requesting that steps be taken to prevent the Eastern States from supplying the Kalgoorlie and metropolitan markets with lemons to the detriment of local growers. For the year ending 30th June, 1935, only 15 cases of Eastern States' lemons were received into Western Australia, so apparently the matter has been righted by the law of supply and demand without any legislative action.

Details of all fruits imported, both from the Eastern States and overseas are as follow:—

IMPORTATIONS OF FRESH FRUIT INSPECTED UNDER THE "PLANT DISEASES ACT, 1914," FOR YEAR ENDED 30TH JUNE, 1935.

Fremantle—		
Olives	39	cases
Bananas	5,528	crates
Grape Fruit	101	cases
Pineapples	1,213	crates
Nuts	3,643	bags
Nectarines	37	cases
Cherries	2,611	„
Plums	85	„
Gooseberries	552	„
Mangoes	4	„
Passion Fruit	38	„
Peaches	13	„
Loquats	5	„
Pawpaws	2	„
		13,871 packages
Kalgoorlie—		
Bananas	4,866	crates
Grape Fruit	29	cases
Pineapples	288	crates
Nuts	107	bags
Nectarines	467	cases
Cherries	695	„
Plums	338	„
Gooseberries	70	„
Pomegranates	7	„
Lemons	15	„
Passion Fruit	43	„
Peaches	972	„
Loquats	34	„
Pawpaws	4	„
Oranges	1,665	„
Cocoanuts	47	„
Tomatoes	626	„
Apricots	84	„
Red Currants	3	„
		10,360 packages
Albany—		
Bananas	49	crates
Pineapples	2	„
Gooseberries	3	cases
Oranges	48	„
Cocoanuts	2	„
		104 packages
Grand Total		24,335 packages

IMPORTATION OF FRESH FRUIT INSPECTED UNDER THE "QUARANTINE ACT," FOR YEAR ENDED 30TH JUNE, 1935.

Bananas	30,216	cases
Bananas (bunch)	18	„
Mangoes	6	„
Pineapples	17	„
Nuts	2,505	bags
Total	32,762	packages

IMPORTS OF FRUIT TREES AND PLANTS.

The young fruit trees brought into Western Australia from the Eastern States show that growers are favouring apples and oranges, enough of the former having been introduced during the year to plant out 250 acres, and of the latter enough for 200 acres.

Details of all kinds of trees and plants are as follow:—

"PLANT DISEASES ACT, 1914."

RETURN OF FRUIT TREES AND PLANTS INSPECTED AT THE PORTS OF FREMANTLE AND ALBANY FOR YEAR ENDED 30TH JUNE, 1935.

Kinds of Trees.	Fremantle.	Albany.	Total.
Apple	14,240	11,099	25,339
Apricot	2,761	746	3,507
Almond	2,621	150	2,771
Cherry	791	65	856
Fig	117	12	129
Lemon	3,798	50	3,848
Loquat	996	6	1,002
Mulberry	507	10	517
Nectarine	1,921	90	2,011
Orange	19,512	25	19,537
Peach	6,881	320	7,201
Persimmon	216	...	216
Pear	2,300	2,234	4,534
Plum	7,739	870	8,609
Quince	170	16	186
Nut	715	20	735
Ornamentals	32,170	1,138	33,308
Currant	444	25	469
Gooseberry	446	75	521
Loganberry	135	...	135
Raspberry	609	25	634
Bulbs and Roots	363,168	125	363,293
Strawberry	600	250	850
Apple Stocks	16,000	...	16,000
Apricot Seedlings	6,500	...	6,500
Peach Seedlings	8,100	...	8,100
Orange Seedlings	4,000	...	4,000
Totals	497,457	17,351	514,808

PESTS AND DISEASES.

The most interesting circumstance in connection with pests that are always with us was the marked lessening of the damage done by fruit fly this year when compared with last. The 1933-34 season was easily the worst since fruit fly first made its appearance in Western Australia, and season 1934-35 was distinctly one of the better ones. One of the causes for the improvement noticed is undoubtedly the wide publication given to the seriousness of the pest which created a fruit fly

conscience, and gave all and sundry people the feeling that they wanted to "swat that fly." The permanent staff of inspectors, the newly appointed honorary inspectors and growers all worked well together, and the results are sufficiently encouraging to warrant still greater efforts being put forward in the coming season.

Unfortunately, another outbreak of Codlin moth occurred this year at Ewington near Collie, but fortunately the outbreak is small, and it is confidently anticipated that it will be subjugated as successfully as those that went before. However, the matter is serious, and all growers are requested to use vigilance in observing anything resembling the pest affecting fruit in their orchards, and to send specimens to the Entomologist of the Department for identification.

Apple Scab—*Venturia inequalis*—that bugbear of the apple grower, has not risen its ugly head during the year, and we can claim its eradication as one of the successes achieved by the combination of growers and departmental officers working in unison.

San Jose Scale, which each year is being legislated against by fresh countries that refuse to permit infected fruit to enter their borders, was more prevalent in Western Australia this year than for a number of years past, and whole-hearted action must be taken by growers to bring this pest under control, for no apples are permitted to be exported that show any evidence whatever of infection.

In the above I have only named a few of the pests and diseases that wait around to harry the man with an orchard, but with these and others the password is "vigilance" and the motto "watch and spray."

FRUIT FLY.

By L. J. NEWMAN, Government Entomologist.

Trapping experiments to test the relative attractiveness of numerous fruit fly lures and the efficiency of various traps have been carried out by the Entomological Branch over a period of five months, commencing on January 25th, 1935, and concluding on Julst 1st.

The lures used were as follow:—

8 ozs. Pollard and 6 ozs. Borax to one gallon of water;

Clensel 1 in 30;

Beeco 1 in 40;

Lura Bane without dilution;

Vanilla and Household Ammonia at the rate of 1 part of each to 26 parts of water.

During the earlier period of the experiment the traps were hung in apricot, pear, peach and fig trees, and citrus trees were used towards the conclusion, when soft fruits were not available.

Early in the experiment the Pollard and Borax lure was abandoned as it proved to be inferior to the other lures with the exception of Vanilla and Ammonia. The latter was continued with, however, as it is the standard lure prescribed in the Eastern States.

In order to test the relative attractiveness of the lures the totals of the flies caught by each lure in the "slip on" trap were compared.

The results were as follow:—

		Males.	Females.	% Females.
Clensel	2,484	988	1,496	60%
Lura Bane	1,672	445	1,227	73%
Beeco	1,060	379	681	64%
Vanilla	560	250	310	55%

From these results it will be apparent that Clensel proved most attractive over the entire period of the experiment, but from the 9th May, an improved type of "Beeco" lure was used and a comparison of the catches from that date shows the following:—

		Males.	Females.	% Females.
Beeco	751	259	492	65.5%
Lura Bane	410	106	304	74.0%
Clensel	225	76	149	66.0%
Vanilla	72	15	57	79.0%

The first three lures, therefore, may be considered efficient. Beeco and Clensel, however, have the advantage of being sold in a concentrated form, and so are cheaper and more economical to use.

Four types of traps were experimented with, viz., the Crystal Glass Trap recommended by the New South Wales Department of Agriculture, the "Simpler," the "Slip On," and "Armstrong's." The last three are locally made traps.

As Clensel gave the greatest number of flies for the duration of the experiment, the totals caught by the various traps containing this lure were compared to prove the relative efficiency of the traps. The following figures were obtained:—

The Slip On	2,484
Crystal Glass	844
Armstrong's	840
Simpler	666

The "Slip On" trap in addition to its catching ability has the advantage of being extremely easy to clean and fill, a consideration not to be overlooked where many traps are being employed.

CARNIOLAN BEES.

The Apiculturist reports that the Carniolan Bees are still giving great satisfaction, and that a large number of orders for queens is in hand at the present time. Anyone requiring queens should therefore place an order at once with the Apiculturist. Delivery by return cannot be guaranteed, but in special circumstances every effort will be made to assist.

THE ORIGIN OF THE WHEAT VARIETY "BENCUBBIN."

R. P. Roberts,

Agricultural Adviser, Department of Agriculture.

In 1934 the variety "Bencubbin" had displaced "Nabawa" as the most popular variety in cultivation in Western Australia, with 649 thousand acres, or 23 per cent. of the total area, sown with wheat for grain.

This variety is a production of the Department of Agriculture. The actual cross and the necessary selections were made by the late E. J. Limbourn, when employed as Cerealist at the Merredin Experiment Farm. The cross between Gluyas Early, the female parent, and Nabawa was made in 1922, with the object of producing a variety that would combine the good qualities of "Nabawa" with the ability to yield well under dry conditions that is characteristic of "Gluyas Early." Five grains were harvested from the cross pollinated ear, and sown the following year. Four of these grains germinated, and gave rise to three plants (*a*, *b*, and *c*) similar in appearance to Gluyas Early, and a fourth (*d*) with a pale brown practically awnless ear.

In the f 2 (second) generation selection *a* gave rise to 205 plants, but amongst these there was nothing considered worthy of selection.

The progeny of selection *b* so closely resembled Gluyas Early that it was obvious that in this case cross pollination had not taken place. These plants were therefore discarded.

Two hundred and six seeds germinated from selection *c*. The early growth of these plants was similar to Nabawa, but as they approached maturity it was seen that a brown eared, weak straw type, predominated. Only two selections, a_1 and b_1, were made from this planting, both of which resembled "Nabawa" in appearance.

From plant *d* 75 seeds germinated, but no selections were made.

Thus, from a total of 475 crossbred plants in the f 2 generation, only two were carried on to the third or f 3 stage.

Of these two selections a_1 appeared to be considerably the better. The plants stooled out well, showed very even growth and practically no variation in ear type. Three plants (*a* 2, *b* 2, and *c* 2) were harvested for further test, but no selections were made from the progeny of b_1.

In the following year, 1926, all the plants raised from selections *a* 2 and *c* 2 were discarded, but 25 were retained from selection *b* 2. These plants had white tapering, tip awned ears, a good straw, showed no tendency to shatter, and had a grain somewhat similar to that of "Gluyas Early."

Traces of rust had been noted on the plants, but rust outbreaks at Merredin are seldom of sufficient severity to allow of any selection for resistance.

The next year the selection, now known as M 31, was found to be practically fixed, slight variations in strength of straw only being noted. In a small scale yield trial the results had been very promising, while in the flag smut test the new variety had proved highly resistant.

In trials extending over the following three years the results obtained were so promising that in 1931 the variety was named, and made available to farmers.

THE PROTEIN, ASH, CALCIUM AND PHOSPHORUS CONTENT OF WESTERN AUSTRALIAN CEREAL GRAINS.

By E. J. UNDERWOOD, Animal Nutrition Officer, Department of Agriculture, and L. C. SNOOK, Research Student, University of W.A.

Whenever cereal grains enter into the rations of livestock it is customary to use standard analyses of these materials in order to estimate the amounts and proportions of the different food elements required. The standard analyses are usually the American figures given by Henry & Morrison [1] or the English figures in the Ministry of Agriculture publication "Rations for Livestock." [2] In each case they represent the average of a very large number of analyses and in general do not differ greatly.

In view of the marked differences between the soil and climatic conditions in Western Australia and those in Great Britain and in the United States of America, however, it becomes necessary to see how far the composition of the cereals of this State conforms to these standards and how far such standards may safely be used in computing rations for our own livestock. This becomes particularly important in the feeding of pigs and poultry, whose rations consist very largely of the cereal grains and their by-products.

Literature.

Work carried out on the effect of environment on the protein content of wheat grain has been well reviewed by Bailey [3] up to 1925. This work shows clearly that the climate in the period immediately preceding ripening—exerts a marked effect on the protein content of the grain. Hot, dry conditions at this time result in a higher and cool moist conditions in a lower protein content. Climatic conditions appear to exert a greater influence on the composition of the grain than other factors such as soils. However, the physical nature and the nitrate content of soils both influence the protein content of the grain. In general also the use of nitrogenous fertilisers, particularly late in the growing period, may be expected to produce an increase in protein content. A large volume of work carried out in many parts of the world since 1925 has fully confirmed these findings with respect to protein variability.

By comparison with the vast amount of data on protein content little information exists as to the mineral content of grains and its relation to environmental conditions. From analyses appearing in the literature, however, it is evident that considerable differences in the mineral content of grains do exist in different parts of the world. For instance, the South African maize used by Theiler (4) contained only 0.42-0.52% P_2O_5 compared with the American standard figure of 0.86%, while barley grown in Alberta by Mather (5) contained 1.30% P_2O_5 compared with the English standard figure of 0.98% on the dry matter.

The most comprehensive study of the influence of environment on the mineral composition of grains is that of Greaves & Hirst (6), who examined wheat, barley and oats grown under a variety of conditions in Utah (U.S.A.) over a period of ten years. They found enormous variation in the total ash, calcium and phosphorus contents of grains during that period. The variations are so large, and the composition, particularly in regard to calcium, so different from accepted standards, that a summary of their results is given in Table A.

Table A.

ANALYSES OF UTAH (U.S.A.) GRAINS (GREAVES & HURST).

		Wheat.	Oats.	Barley.
Percentage Total Ash	Maximum	2·94	4·87	3·71
	Average	1·85	4·05	3·00
	Minimum	1·35	1·68	2·08
Calcium (CaO)	Maximum	0·414	·238	·216
	Average	·126	·168	·120
	Minimum	·039	·024	·041
Phosphorus (P_2O_5)	Maximum	1·069	1·052	1·023
	Minimum	·772	·849	·819
	Average	·350	·623	·747

In discussing these results Greaves & Hirst conclude that soil conditions are the principal factors influencing mineral composition. Variety also influences mineral composition but is stated to be the least important factor.

The experiments of Mather (5), previously quoted, indicate that phosphorus fertilisation has little or no influence on the phosphorus content of the grain of wheat and barley though capable of markedly raising the phosphorus content of the straw. This finding is supported for wheat, oats and rye by Weidemann (7) in U.S.A.

Little appears to have been done in Australia on the composition of cereal grains from the point of view of animal nutrition, though a considerable amount has been done on the protein content with relation to the baking quality of Australian grains. In 1926, however, Brunnich (8) published analyses of a number of Queensland feeding stuffs, carried out between 1910-1914. These included maize, wheat and the wheat offals, bran and pollard. The average figures given for calcium and phosphorus are, in the case of the cereals, only slightly lower than the "standard" English figures, but the variability is very large. Thus the range of concentration for wheat is 0.03-0.08 (mean 0.06) per cent. CaO and 0.34-0.96 (mean 0.86) per cent. P_2O_5 in the dry matter. For maize the corresponding figures are 0.01-0.07 (mean 0.02) per cent. and 0.60-0.86 (mean 0.70) per cent.

More recently Dadswell (9) has shown the total ash content of Victorian and New South Wales wheat to be significantly lower than that of overseas wheat. In the ten years 1925-1934, the ash content of the yearly F.A.Q. samples of Victorian wheat ranged from 1.39-1.66% on the dry matter, with an average of about 1.5%. Overseas wheat contains, in general, at least 1.8-2.0% total ash. The lower ash content of the wheats of eastern Australia was found by Dadswell to be reflected, in general, in lower percentages of all the major mineral constituents, potassium, phosphorus, magnesium and calcium.

Present Investigation—Materials and Methods.

Samples of wheat, oats and barley were collected from the State Experiment Farms at Chapman, Wongan Hills and Merredin for each of the three years 1932, 33 and 34. The same variety was used in each case and the general cultural and manurial practices used in producing the crops were very similar. The soil and climatic conditions differ greatly, however, at the three farms. Chapman Experiment Farm is characterised by medium to poor soil with comparatively heavy rainfall and slower ripening period: Wongan Hills Light Lands Farm by very poor sandy soil and a similar growing and ripening period, and Merredin Experiment Farm by comparatively heavy soil, low rainfall and quicker ripening period. The average monthly rainfall for these farms is given in Table 1.

TABLE 1.

AVERAGE MONTHLY RAINFALL FOR CHAPMAN, MERREDIN, AND WONGAN HILLS EXPERIMENT FARMS.

Farm.	Useful Rains. Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total for Year.	No. of Years (Average for).
Chapman	29	41	77	62	246	426	395	278	161	97	1,603	32	27	1,871	29
Merredin	50	50	113	95	132	187	188	151	87	83	828	44	52	1,232	23
Wongan Hills ...	31	31	97	94	169	255	290	204	87	96	1,101	30	38	1,422	9

Samples of the official F.A.Q. sample of wheat from the Perth Chamber of Commerce, were also obtained for the five years 1927-8, 1929-30, 1930-31, 1933-34 and 1934-35. This may be taken as representing the average quality of wheat produced in Western Australia for the years in question.

In each case samples analysed consisted of clean seed freed of obvious impurities by handpicking. In this way a more definite basis for comparison was obtained.

A small number of samples of the wheat offals, bran and pollard were also obtained from different merchants.

The samples were all ground to a fine powder in a small hand mill and analysed in duplicate for moisture, total nitrogen, total ash, calcium and phosphorus. The nitrogen determinations were carried out by the ordinary Kjeldahl method. The factors used for converting the N to crude protein percentages were—Wheat, barley and oats 5.83, pollard 6.25 and bran 6.31. With the exception of pollard, which is not stated, these are the conversion factors given by Jones (10).

Calcium was determined by the permanganate titration method and phosphorus colorimetrically on the ash, after careful ashing at a dull red heat with a few mls. of 10% magnesium nitrate solution. The phosphorus results were checked by a number of determinations using the volumetric molybdate method after wet digestion.

RESULTS.

WHEAT.

The results of analyses of the W.A. samples of wheat are given in Table 2, together with the "standard" British and American analyses for comparative purposes. The Experiment Farm analyses are in all cases for the common midseason variety Nabawa.

TABLE 2.

COMPOSITION OF W.A. WHEAT.

Place of Origin.	Year.	Dry Matter.	Crude Protein.	Total Ash.	Calcium CaO	Phosphorus P_2O_5
		%	%	%	%	%
Merredin Experimental Farm ...	1932	90·8	11·1	1·5	·05	0·57
,, ,, ,, ...	1933	90·8	12·6	1·5	·05	0·50
,, ,, ,, ...	1934	88·6	12·6	1·3	·05	0·49
Chapman Experimental Farm...	1932	90·3	9·3	1·4	·05	0·59
,, ,, ,, ...	1933	90·0	8·1	1·5	·03	0·76
,, ,, ,, ...	1934	88·0	9·3	1·5	·06	0·74
Wongan Hills Lightlands Farm	1932	90·4	7·8	1·4	·05	0·49
,, ,, ,, ...	1933	90·9	8·6	1·4	·05	0·41
,, ,, ,, ...	1934	88·5	8·8	1·2	·04	0·49
State Average F.A.Q.	1927	90·3	10·0	1·5	·05	0·47
,, ,, ,, ...	1929	90·6	10·8	1·4	·05	0·48
,, ,, ,, ...	1930	91·0	10·0	1·4	·05	0·49
,, ,, ,, ...	1933	90·2	10·4	1·3	·05	0·48
,, ,, ,, ...	1934	88·7	10·6	1·2	·04	0·47
Mean of F.A.Q. Samples ...	...	90·0	10·2 10·9	1·4	·05	0·48
Standard English	...	86·6	12·1	1·7	·05	0·86
Standard American	...	89·8	12·4	1·9	·06	0·86

Crude Protein.—The F.A.Q. samples, which represent the average wheat produced in Western Australia in each year are remarkably constant in protein content for the five years sampled between 1927-8, and 1934-5. The average for this period is just over 80 per cent. of the "standard" English and American figures. It must be noted, however, that the factor nitrogen x 5.83 was used in calculating the protein percentages of the W.A. samples, instead of the older conversion factor of 6.25 used in the "standard" figures. The mean protein content of the Western Australian wheats is therefore actually almost 90 per cent. of the "standards."

Considerable variation in protein content of wheat is shown at the three centres from which samples were obtained. As would be expected from results in other parts of the world, the drier climate, shorter ripening period and heavier soil at Merredin has produced a markedly higher protein content wheat than that of the other two centres. The fact that the Wongan Hills samples are slightly lower than those from Chapman, though the climatic conditions at ripening tend to be rather more favourable to a high protein wheat at Wongan Hills, suggests that the poor light sandy soil at Wongan Hills is an important factor in reducing the protein content of the wheat. It is evident from the analyses that wheat from the eastern districts of the State must in general be a much better source of protein than that from other wheat areas in the State, since both the heavier soils and the drier climate tend to produce this result. It is probable, however, that the protein content of grain from the eastern districts would not be nearly so high if grown on some of the poor sandy soils of those parts.

Total Ash.—The mean ash content of the F.A.Q. samples is about 80 per cent. of the "standards." Little variation exists in the wheat from the different parts of the State. The ash content of the 1934 samples, however, appears in all cases to be slightly lower than in the other years. The results are closely similar to those given for Victorian wheats by Dadswell (9).

Calcium.—The mean calcium content of the F.A.Q. samples is identical with the English standard figure and only very slightly below the American figure. The samples show no consistent variation from place to place or year to year.

Phosphorus.—The percentages of phosphoric acid in the F.A.Q. samples show little variation and are remarkably low compared with the "standard" figures. The mean of these samples is only 55 per cent. of the English and American analyses and is lower also than any of the figures given by Dadswell (9) for Victorian F.A.Q. wheat.

The Wongan Hills and Merredin figures are very similar to the average, but the Chapman analyses are much higher, though even these average only 81 per cent. of the standard. The higher phosphorus content of the Chapman grown wheats is very interesting. It is quite likely that this is due to the milder climate and hence quicker growing conditions in the early part of the season in those parts, since it has been shown by many workers that most of the plant's phosphorus is absorbed in the first few weeks of growth. The superphosphate added at seeding time quickly becomes unavailable in Western Australian soils (Teakle) (11) and it is those plants which grow quickest at the start which are likely to absorb the most phosphorus.

From the F.A.Q. figures it is evident that the Chapman percentages are not at all general in the wheatbelt unless a considerable portion of the State yields wheat with phosphorus percentages even lower than that grown at Wongan Hills.

OATS.

The results of analyses of the samples of oats are given in Table 3. No F.A.Q. "blend" representing the whole of the grain produced in the State in any year, is available for oats. Analyses of samples from the three State Experiment Farms are given for the three years 1932-3-4, together with two samples from the Nungarin district near Merredin. The common early variety Mulga was taken in all cases.

TABLE 3.

COMPOSITION OF W.A. OATS.

Place of Origin.	Year.	Dry Matter.	Crude Protein.	Total Ash.	Lime CaO	Phosphorus P_2O_5
		%	%	%	%	%
Merredin Experimental Farm ...	1932	91·1	10·7	3·55	0·08	0·51
" " " ...	1933	92·6	10·6	2·88	0·07	0·46
" " " ...	1934	90·1	10·5	2·74	0·09	0·46
Wongan Hills Lightlands Farm	1932	91·8	7·4	3·22	0·08	0·49
" " "	1933	92·1	7·3	3·24	0·08	0·44
" " "	1934	90·1	8·4	2·52	0·08	0·36
Chapman Experimental Farm...	1932	92·0	6·7	3·74	0·12	0·55
" " " ...	1933	91·5	9·1	3·28	0·07	0·67
" " " ...	1934	90·0	6·7	3·34	0·10	0·56
Nungarin District	1932	90·4	10·9	3·49	0·08	0·50
" "	1933	90·1	10·0	2·73	0·09	0·50
Average	...	91·1	8·9	3·33	0·09	0·50
Standard English	...	86·7	10·3	3·10	0·14	0·81
Standard American	...	90·8	12·4	3·50	0·14	0·81

Crude Protein.—The crude protein content varies considerably in the four places sampled, though not to quite the same extent as in the case of wheat. As with wheat the drier, hotter districts with the heavier soils, represented by Merredin and Nungarin, have produced grain of decidedly higher protein content than Wongan Hills or Chapman. The average of the Merredin and Nungarin samples is 10.5 per cent. compared with 7.6 per cent. in the six samples from Wongan Hills and Chapman.

The eleven samples analysed average 8.9 per cent. crude protein, which is about 86 per cent. of the standard English figure and only about 72 per cent. of the standard American figure. As pointed out in the case of wheat, however, it must be noted that the difference is actually not quite so large since the "standard" protein percentages were calculated by multiplying the nitrogen percentage by 6.25, instead of the more modern factor 5.83 used in the Western Australian analyses.

Total Ash.—The mean ash content, 3.33 per cent., is very similar to the standard figures. The variation is considerable but the differences do not appear to be correlated either with the season or the district.

Calcium.—The mean calcium content of the Western Australian samples is only 64 per cent. of the standard analyses. This is surprising in view of the results with wheat. The variation is not large except with the Chapman samples, which ranged from 0.12% CaO in 1932 to as low as 0.07% CaO in 1933.

Phosphorus.—The mean percentage of phosphoric acid is 0.50% P_2O_5, or only about 62 per cent. of the English and American figures. The difference in favour of the standard analyses is not quite so great as with wheat but is still extremely large. All three of the Chapman samples are higher in phosphorus than any of those from the other districts. The explanation of this result, as suggested, for wheat, is possibly the quicker growing conditions of this district in the early part of the season.

FEED BARLEY.

Feed barley is grown very little in Western Australia compared with wheat or oats and only five samples were obtained. Three of these were from the drier eastern districts near Merredin and Nungarin. The samples were of the Cape Barley variety with the exception of the sample from Quairading, which was of the variety California Bay. The analyses are given in Table 4.

TABLE 4.

COMPOSITION OF W.A. BARLEY.

Place of Origin.	Year.	Dry Matter.	Crude Protein.	Total Ash.	Calcium CaO.	Phosphorus P_2O_5.
		%	%	%	%	%
Quairading	1933	89·2	7·9	2·0	·05	·49
Nungarin	1933	89·8	11·3	2·0	·06	·55
Merredin Experimental Farm ...	1933	92·0	11·4	2·1	·08	·55
" " ...	1934	89·5	11·5	1·9	·05	·37
Wongan Hills Light lands Farm	1934	89·1	8·9	1·6	·05	·39
Average		89·9	10·2	1·9	·06	·47
Standard English		85·1	8·6	2·6	·07	·84
Standard American		90·7	11·5	2·7	...	...

Crude Protein.—The protein content of the five samples analysed averages decidedly higher than the figure given for English feed barley, and if the difference in the method of calculation of protein from nitrogen is taken into account, it is very close to the figure given for American barley. At the same time it must be noted that three of the five samples are from the dry eastern districts and contain very high percentages of protein. The other two samples from districts with slightly longer ripening periods and lighter soils have protein contents no higher than the English figure. As in the case of wheat and oats it is apparent that the drier districts with their heavier soils are capable of producing barley of much higher protein content than other parts of the State.

Total Ash.—The ash content is fairly constant and the mean only about 70 per cent. of the "standards."

Calcium.—The percentage of CaO varies from .05-.08 per cent. with a mean of .06 per cent., which is very similar to the figure for English barley.

Phosphorus.—The percentage phosphoric acid in each sample is much lower than the standard English figure of 0.84 per cent. The two 1934 samples from Merredin and Wongan Hills contained the extremely low amounts of 0.37% and 0.39% P_2O_5 respectively. These two samples average only 45 per cent. of the "standard." The three 1933 samples are not nearly so low as this but they average only 63 per cent. of the "standard."

Cereal By-Products.

WHEAT BRAN.

Five samples only were obtained. One of these was from the milling of a "strong" wheat, one from Merredin wheat, and the other three from wheat of mixed origin. The results of analyses are given in Table 5.

TABLE 5.

COMPOSITION OF W.A. BRAN.

Nature of Sample.	Dry Matter.	Crude Protein.	Total Ash.	Calcium CaO	Phosphorus P_2O_5
	%	%	%	%	%
From strong wheats	90·2	13·4	4·0	·09	1·48
From Merredin District	89·0	15·3	3·2	·11	1·23
Mixed Sample	90·5	13·8	3·7	·09	1·24
Do.	89·5	12·7	4·4	·10	1·44
Do.	86·0	13·5	3·3	·07	1·37
Average	89·0	13·7	3·7	·09	1·35
Standard English	87·0	14·7	5·8	·20	2·80
Standard American	89·9	16·0	6·3	·09	2·95

Crude Protein.—With the exception of the Merredin sample, which is quite high, the variation in protein content of the bran samples is not large. The average compares favourably with the English figure for bran and is as much as 86 per cent. of the very high figure given for American bran.

Total Ash.—The total ash percentages of the Western Australian brans are markedly lower than the standard English and American figures. The differences are rather larger than would be expected from the wheat analyses.

Calcium.—The calcium content of the five samples is fairly constant and the mean is identical with the American figure. It is, however, only 50 per cent. of the English standard. The very high figure given for English bran is rather difficult to understand.

Phosphorus.—As would be expected from the analyses of wheat, the phosphorus content of Western Australian brans is markedly lower than the "standard" figures. The mean of the four samples is actually only 48 per cent. of the English figure. As was noted with the total ash percentage, the difference is slightly greater than would be expected from the figures for whole wheat. It is possible that this difference is due, at least in part, to the slightly lower percentage extraction of flour in Western Australian milling practice compared with English mills.

POLLARD.

Five samples of pollard comparable with the brans were obtained for analysis. The result of the analyses are given in Table 6. Pollard is the name given in Western Australia to the whole of the material intermediate between bran and flour obtained in the milling of wheat. There is usually no material in English or American milling practice strictly comparable with Western Australian pollard, owing to the practice in those countries of producing two or more products intermediate between flour and bran. The most common names given to such materials in England were coarse, medium and fine middlings. An attempt has been made recently by the Research Association of British Flour Millers (12) to standardise these wheat feed materials to two grades known as Weatings and Superfine Weatings. No mineral analyses for these grades are at present available to the writers. The analyses of English coarse middlings and American middlings will be included for comparative purposes, though it must be realised that a true comparison cannot be made.

TABLE 6.

COMPOSITION OF W.A. POLLARD.

Nature of Sample.	Dry Matter.	Crude Protein.	Total Ash.	Calcium CaO	Phosphorus P_2O_5
	%	%	%	%	%
From strong wheats	90·2	12·2	1·8	·06	0·68
From Merredin District	89·0	12·1	1·4	·06	0·45
Mixed Sample	92·0	14·9	2·7	·08	0·91
Do.	88·8	13·9	2·5	·09	0·84
Do.	88·0	12·6	2·1	·06	0·82
Average	90·0	13·3	2·1	·07	0·72
Coarse Middlings (English) ...	86·0	15·9	3·7	·10	2·60
Middlings (American)	89·5	17·4	4·4	·08	2·11

Crude Protein.—The crude protein content of the pollards varies from 12.1% to 14.9%. The average of the five samples, 13.3%, is about 83% of the English figure for coarse middlings but only 76% of the corresponding American figure. It is interesting to note that the pollard from wheat grown in the Merredin district is actually the lowest in protein content. The extremely low figures for ash and phosphorus in this sample suggests a very poor extraction of flour in this particular case. It must be pointed out also that three of the five samples of pollard analysed contained no more crude protein than Merredin whole wheat.

Total Ash.—The total ash content of each of the five samples is very much lower than the figures given for English and American middlings.

Calcium.—The calcium contents of the pollards are all rather lower than the English standard for middlings but only three of the five are lower than the American figure.

Phosphorus.—The phosphoric acid percentages are strikingly low compared with the analyses of overseas middlings given. The mean of the five samples is 34% of the American figure and only 28% of the English figure for middlings. The sample from Merredin, as mentioned earlier, probably contains a large amount of flour, as it has only 0.45% of phosphoric acid. This is practically identical with the figure for whole wheat. Even without that sample, however, the other four average only 0.81% P_2O_5, which is less than 40% of the standards.

It must be again pointed out that the comparison of Western Australian pollards with overseas middlings is not really sound, since the Western Australian samples contain all the material intermediate between flour and bran and the overseas samples do not. It is imperative that further complete analyses of Western Australian pollards be carried out though it is already apparent that our pollard, at least in respect to protein and mineral content, is frequently not greatly superior to whole wheat.

DISCUSSION.

It is apparent from the analyses given that Western Australian cereal grains and wheat offals differ in a number of important respects from English and American cereals and wheat offals. In some cases these differences are sufficient to markedly influence their nutritional value.

The value of the Western Australian materials as sources of protein depends very largely on their place of origin. Wheat, barley and oats grown on the heavier soils and drier climate of the eastern wheat belt compare more than favourably with the overseas "standards," but when grown on lighter soils, as at Wongan Hills, or in a wetter climate with a longer ripening period, as at Chapman, they contain considerably less protein. It is obvious that the cereals grown in the drier areas and on heavier soils will, in general, have a much higher nutritional value, particularly in the feeding of pigs, poultry and dairy cows, than those from other parts, since they will need supplementing with smaller amounts of expensive protein concentrates. Grown under similar conditions in Western Australia, wheat is a rather better source of protein than barley, and barley than oats. Under average English and American conditions, oats are apparently higher in protein than barley.

In mineral composition, however, there are much more striking differences. Western Australian grown oats appear to contain about the same proportion of total ash as the "standards," but local wheat and barley is comparatively less well supplied with ash. Undoubtedly a large part of this deficiency in ash is due to the extreme poverty of the local grains in total phosphorus, but there must also be some deficiency in other mineral elements. If this deficiency were chiefly potassium and magnesium, two of the principal mineral elements in grains, it would have little nutritional significance since these two elements are usually very plentifully supplied by practically all diets. A lowering from "normal" values in sodium and chlorine, however, would have decided significance as these two elements are already very low even in "normal" grains. Further investigation into the mineral composition of Western Australian cereal grains is greatly needed.

The very low values for phosphorus of Western Australian wheat, barley and oats, are of great nutritional importance. A single instance in the rationing of pigs with these cereals will be sufficient to illustrate this. According to recent experiments by Dunlop (13) the optimum intake of phosphorus for pigs between 30 and 200 lbs. live weight, gaining from 1.0-1.4 lbs. per day, lies between 1.22-1.38% P_2O_5 (0.53-0.6% P.) on the dry matter of the ration. A ration frequently used in Western Australia consists of 90-95% wheat-meal and 5-10% meat-meal. Assuming the meat-meal to contain 5% P_2O_5, a simple calculation shows the ration to be decidedly deficient in phosphorus for optimum growth rates. A small mineral supplement of either bonemeal or dicalcic phosphate, as well as salt, should therefore be fed where rapid growth and economy of gain is required. This is contrary to accepted theory and practice, not only with pigs, but also with poultry, as numerous experiments in Great Britain have shown lime and salt to be the only minerals required to supplement the usual cereal rations of these animals. This is true, not only because of the high phosphorus content of the whole grains used in Great Britain, but also because of the almost invariable inclusion in the rations of that country of a proportion of middlings or shorts which contain on the average over twice the percentage of phosphorus as the whole grain. In Western Australia, however, the position is apparently quite different as the local grains contain only about half the phosphorus of the English grains, and local pollard only about one-third that of English middlings.

SUMMARY AND CONCLUSIONS.

1. Fourteen samples of wheat, eleven of oats, and five of feed barley, grown during the last three years in different parts of Western Australia, were collected and analysed for total protein, total ash, calcium and phosphorus. Five samples each of bran and pollard were also obtained and analysed for the same constituents.

2. The analyses showed that Western Australian grown wheat and oats is slightly lower, and feed barley slightly higher in total protein, on the average, than "standard" English analyses. Considerable variation exists, however, in grain from different parts of the State. The eastern districts produce grains much richer in protein than those from other parts of the States. It is suggested that this is due both to the drier climate and the heavier types of soils of those parts.

3. The total ash content of locally grown oats is very similar to overseas "standards" for this cereal, but the ash content of local wheat and barley is only about 80 per cent. of the corresponding standards.

4. The calcium content of local wheat and barley is very similar to the "standard" analyses. Local oats, however, are appreciably lower.

5. The phosphorus content of Western Australian wheat, oats and barley is markedly lower than that of English grains. Usually they contain only about 50 per cent. of the phosphorus of the standards. In 1934 one sample of oats contained only 0.36%, and two samples of barley only 0.37% and 0.39% total P_2O_5 as compared with English "standard" figures of 0.81% and 0.84% for oats and barley respectively.

6. As would be expected from the wheat analyses Western Australian bran contains, on the average, slightly less protein, much less ash and only about 50 per cent. of the phosphorus of English bran. Western Australian pollard is even more deficient in protein, ash and phosphorus compared with English middlings. Frequently, Western Australian pollard is not greatly superior in these constituents to whole wheat.

7. The nutritional significance of the above findings is briefly discussed.

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POULTRY FARMING FOR THE BEGINNER.

Part 5.

FAILURES IN INCUBATION.

G. D. Shaw, Poultry Adviser, Department of Agriculture.

Dead in Shell.—This is the general term given to those chicks which, through some reason or other, fail to emerge normally from the shell.

Operating the incubator strictly to directions will naturally tend to reduce the dead in shell, but there are other factors which are likely to interfere with the obtaining of a good hatch.

Too little moisture is generally the first thought when trying to find the fault, but it is suggested that the incorrect control of ventilation will be the most common cause. It must, first of all, be realised that the egg itself contains sufficient moisture whereby a perfect hatch can be obtained, but to guard against the effect of faulty incubation, it is safer to add a moisture tray below the eggs and replenish it as required. When the germ has died before the seventh day of incubation, one can generally assume that *the initial heat was too great* and caused a rupture through the egg being subjected to too marked a contrast when first placed into the machine. Never raise the temperature too quickly—up to 24 hours will not harm the germ nor arrest normal development.

Germs will also die before seven days old if *they have been stored for over* 10 *days before setting.* It is advisable to set eggs as often as possible. The older the egg, the weaker the germ, and so the aim is to put down eggs under seven days old.

Another factor operating against the embryo is the *storing of incubator eggs in too cold a temperature.* This has the tendency to kill or weaken the germ. *Any tendency to excessive ventilation* when storing is another cause of early deaths during incubation. Do not store the eggs where they may be subjected to draughts. Should the hatch take longer than the twenty-one days, it is certain that the *running temperature has been too low.* It is quite a common fault to err on the

safe side by running the machine a fraction less than 103deg. The result is a late hatch. A "late" hatch is sometimes bewildering. The machine has been at 103deg. on each inspection and yet the hatch is slow. The thermometers are known to be correct, having been tested before operating, and they have been kept at the right height in the tray. We must then consider that the machine has been running low during the night time.

It is a usual practice to examine the machine at 10 p.m., and if it is running at 103deg. retire for the night, and reinspect at 6 or 7 a.m., when the temperature is still at 103deg. Naturally it is assumed that the machine has been steady for those nine hours.

When it is recognised that the outside temperature is gradually reducing until 4 or 5 a.m., we will then realise that our machine has been running low during that period also. Were an examination made of the temperature at 3 a.m., we would be tolerably surprised to find the thermometer registering 100deg. or even lower. *This continuous drop nightly will have a distinct bearing on a late hatch.* To remedy this fault the drop must be counteracted by continuous adjustment of the thermostat during that period. This does not mean that night shift should be worked, but it does mean that one should arise and adjust the lamp whenever a cold snap is expected.

On the other hand, should the hatch be completed in less than 21 days, *the temperature has been too high.* If the advance in hatchings is of a few hours only, no adjustment is required, but the greater fault is when the hatch is completed before the *middle of the twentieth day.* It is generally accompanied by troubles such as deformed chicks, unabsorbed yolks, crooked legs and bent toes, blind eyes, and crossed beaks. The hatch will naturally be a bad one and very few chicks will be of any use—never try to persevere with deformed ones.

Too much moisture is not a common fault in W.A., but too little is frequent. It is usually caused by excessive ventilation.

When the chicks have broken the full circle of the shell and have then failed to emerge because the fluff has dried and is adhering to the broken shell, one can be positive that there has been insufficient moisture. The remedy is obvious. If the water tray has been constantly replenished the ventilation must be checked. It may be too fast. Watch the drying down of the air cell more closely. This is the best gauge. But should the chick barely pierce the shell and appear glued thereto or the chick have cut right around and cannot emerge because of a stickiness, the cause is lack of ventilation. Any gumminess is a definite indication of lack of oxygen and requires greater ventilation to overcome it.

Dead in shell at the eighteenth day may be due to many causes, but assuming the machine has been carefully operated, lack of vitality in our breeding stock is indicated. Experience in incubation, when one knows the different characteristics of each machine, suggests that when chicks are found dead in the shell at the eighteenth day, we should look to the breeders. The breeders are the unknown quantity on a poultry farm. So much has been written about the subject of good breeding stock it seems superfluous to add more, but it is definite that most incubating failures are due to the breeders. With the beginner at poultry farming this is intensified.

It is definitely hard to impress upon the beginner that his foundation stock means success or failure. Only experience convinces him, but that experience is often dearly bought. We must still persevere with that old stock phrase, "Purchase only the best of tested stock as your foundation."

Once a defect has been bred into a strain it is never lost, and it takes years and years of selection to keep it in check—even then it crops up at the most inopportune times. Generally, in the incubator it is found when the chickens lack that vitality necessary to emerge from their shells. No matter how perfectly heat, moisture, and ventilation are adjusted, we can never assist low vitality.

Strong healthy chicks are not hatched from eggs that lack vitality, and no amount of care will strengthen the germs. Even if the germs can develop or hatch into a chick, no amount of feeding will make that low vitality chick develop into a profitable producer.

The breeding flock must be of the best, and by now the beginner will have realised that something is wrong. Look to the original stock and correct the low vitality by using the best procurable strain next season. Temptations are always before us. Never help a chick to emerge from the shell. If it cannot emerge by its own energy, it lacks vitality and will never do any good for itself or its owner.

All chickens which do not appear perfect should be immediately destroyed. The first loss is the cheapest.

Another phrase hard to teach is, "Do not tolerate the unthrifty chicken."

Faulty turning will cause the germ to adhere to the shell. When testing you will notice a small spot on the shell. When rotated this spot does not move. Take care to turn the eggs thoroughly.

A small blood ring denotes that the eggs have been heated too quickly or have had a jar some time before setting.

If the eggs get chilled through allowing them to cool off for too long a period the hatch may be spoiled. This is generally obvious and will naturally impress the beginner without any further comment.

FAULTS IN THE OPERATING OF THE MACHINE.

Smoking lamps are mostly due to poor oil (only the best of kerosene must be used), and unless rectified a bad odour will penetrate the machine and spoil the hatch.

Uneven temperatures on the tray will cause an uneven hatch and most likely kill all the chickens. See that the machine is level and that the temperature is even at all parts of the tray. Any unevenness of heat will be noticed on the first test. Eggs in certain portions of the tray will be further developed than those in other positions. Germs dead in one section of a tray are generally an indication of uneven temperature. Always turn or test the eggs before filling the lamps with kerosene. Any kerosene taint coming in contact with the eggs from dirty hands will kill the germ.

Many a good chick has been killed at the fourteenth-fifteenth day of incubation. At this period the embryo has developed to such a stage that it is generating a large amount of animal heat. This animal heat, together with the artificial heat supplied, will raise the temperature higher than 103deg. unless the operator allows that surplus artificial heat to escape by way of a raised damper. This overheating will cause the death of otherwise healthy embryo, and operators should pay close attention to their machines during this period.

Again, at the eighteenth day the temperature will begin to rise suddenly. It is here advisable to turn the lamp low—but the damper must still be floating. The animal heat generated at this period is three or more degrees, and unless counteracted by less artificial heat, will damage the young chicken.

To be successful at artificial incubation the operator must intelligently apply moisture, ventilation and heat, for without these he cannot expect success.

POTATO CULTURE—ITS PROBLEMS.

Questions asked and answered.

E. T. MORGAN and W. E. COLLINS, Potato Branch, Department of Agriculture.

The following series of questions and answers are the outcome of correspondence received at this office from a grower in the Great Southern district. Although written in response to his numerous queries, it was considered they would be of interest to other growers—hence their publication in the *Journal of Agriculture*.

Would lime be benficial on hill soil not subject to Scab?

Practically all of the soil types utilised for potato growing in this State are known to be fairly acid, and that potatoes tolerate this condition is also well known, but its effect on yields and growth is not too well understood or appreciated.

The effect of acid soil conditions on growth is not always apparent with clear cut symptoms, thus other factors such as seed, fertiliser used, etc., are often blamed instead. That too acid a soil reduces yields is recognised by some growers, who term it "sourness," but the fear that overliming may be equally injurious by reason of it causing Scab conditions, has reduced its use to a negligible quantity. With the development of simple tests for acidity the individual grower can eliminate this gamble in potato production if he will avail himself of such tests. The test for soil acidity, or rather the need of lime, is as follows:—

> "Place some soil in a cup or glass with a trowel, not with the hand. Make it wet enough so that it can be stirred with a stick. Open a slit in the soil with a knife blade, and insert a piece of blue litmus paper, obtained at a drug store. Press the soil against the paper. In an hour remove the paper. If it is distinctly pink, almost to red, the soil is extremely acid. If it is only faintly pink the soil is slightly acid. Soil testing outfits with simple directions and colour chart may be obtained reasonably cheaply from any of the wholesale druggists."

There is much evidence to show that yields may be increased by applying small quantities of lime to soils without changing the soil reaction sufficiently to cause injury from Scab organisms. In using lime on potato fields only small quantities should be used at one time. A single application should rarely exceed half a ton of ground limestone to the acre. After this initial application has had time to react with the soil, and a test indicates that too high acidity still persists, a second small application may be made. Thus, the highest yields of marketable potatoes will be obtained when the soil is kept just sufficiently acid to guard against serious losses from Scab. Ground limestone has been mentioned as the medium for introducing lime to soils. This is just common limestone rock that has been passed through a crushing or pulverising machine. To insure quick results, limestone should be finely ground. The general effect is similar to that of any other form of lime, and it has a number of advantages. It is not so caustic in its action, and is in a more convenient form to handle and apply. It can be uniformally distributed, and there is no irritating effect upon the eyes and nose. Should unsuitable weather occur, it can be held over until better conditions prevail, and, if necessary, it may be stored for use the following season without fear of deterioration or destruction of bags. The best time for application is three to four weeks prior to planting.

Does it pay to plant the autumn crop very close? Can this be used as a method to smother weeds? Does it force stronger growth?

A safe, general rule to follow in planting autumn potatoes is to increase or decrease the distance between the rows and sets, in accordance with the fertility of the soil, its moisture holding capacity, and the average normal rainfall that may be expected when the plants are developing their tubers. The nearer the soil and weather conditions approach the ideal, the wider the planting. Too close planting in heavily fertilised soil would tend to spindly growth of tops, which would eventually be beaten down by heavy rains and strong winds, thus reducing the chances of equivalent crops with those that have the space to respond naturally to growth.

The measurements most in favour for autumn planting are 27 inches between the rows and 15 inches between the sets. Instances have been noted and recorded of plantings at much lesser distances between rows and sets, with increased yields over those of the wider spacing, but these may be ascribed to some outside factor.

If the soil is addicted to weeds, it would be advisable, on prepared land, to await the first strike of weed seed, then plough these under when planting, thus leaving a clean cover. Well forward, sprouted seed would then have every chance of coming away quickly, so smothering many of the second crop weeds, should other buried weed seed germinate.

Potatoes may be harrowed when plants are three to four inches in height without appreciable injury.

What are the advantages of large sets over small ones in round seed especially?

The question of size of seed, and whole or cut sets, has engaged the attention of growers the world over for many years, and is still not fully answered. The superiority of whole, over cut seed, or of cut seed over whole, has been repeatedly demonstrated for both; and a grower who studies the subject soon arrives at a point where he is convinced that the superiority of whole or of cut seed is one of environment rather than of actual influence of seed.

It will be found that too large or too small sets, whether they are whole or cut, are not economical to use. Generally speaking, it is advisable to use a liberal size of seed. In the case of small cut sets, if the soil is dry and hot, many of the pieces will fail to grow. A blocky set weighing from one and a half to two ounces is less likely to dry out or decay in the ground if the weather conditions are unfavourable. Moderately cool temperatures at the time of planting are an essential to success with cut sets, in conjunction with soil in good heart, they will assuredly yield a larger proportion of shapely marketable tubers than whole seed.

The use of whole seed in a hot dry season is safer and only less desirable on account of its habit of producing more stems, also to its inherent tendency to set a larger number of tubers per stem, resulting in a greater proportion of the crop being of medium size only.

If the production of whole round seed is aimed at, no better system could be followed. The seed tubers should be selected from good stock, and the amount of fertiliser considerably reduced.

Is it satisfactory to force seed potatoes to sprout by dipping them in a solution of sulphate of ammonia?

On reviewing the experimental evidence, as set out by various workers, it would appear conclusive that the shortening of the rest period of the potato by chemical agency can be accomplished, but, so far as can be learned, there are no figures indicating effects on resultant crops from such treated tubers. Mention is made of

definite injury to foliage in some instances. Until this aspect is demonstrated satisfactorily, we do not feel justified in advocating the subjecting of seed potatoes to chemical treatment to abridge the rest period.

Many and varied were the gases and solutions tried, and of approximately 224 substances tested over four years, it was found that ethylene chlorhydrin gas was on the whole, the most effective in hastening germination. Working on a variety whose normal rest period is 90 days, it is claimed that this was reduced to 21 days. Ammonia and nitrate of soda solutions were included in the tests, but these were much below the recordings for the above-named gas.

Early Blight—Does it pay to spray?

The only satisfactory preventive measure is that of keeping the plants thoroughly sprayed with Bordeaux mixture, which very efficiently protects plants from attacks of this disease.

Spraying experiments over several years at different centres showed increases in yields of the sprayed plants over the unsprayed plants, of from 16 to 55 per cent. The economic importance of the Early Blight, as judged by the damage it does to the tubers in storage, is considerable.

This present season has been a particularly bad one for Early Blight, and many tons of potatoes must be wasted in consequence. The losses sustained are, as a rule, much greater than the average grower realises. It may be asserted that quite 15 per cent. of the stocks now held will never be marketed because of this trouble, which goes to prove the absolute necessity of spraying, if growers would avoid these losses. Thoroughness of application cannot be over emphasised in spraying for Early Blight, and complete control can only be attained by fortnightly sprayings, begun when the plants are six to eight inches in height and continued throughout the remaining period of growth.

Where should seed be stacked? In the open or under cover? Do marketable potatoes keep in a more satisfactory condition if stacked in the open? Does it pay?

Seed, when stacked, should be placed somewhere in the light, if greening, and the checking of the sprouts be desired, but not, of course, actually in the direct rays of the sun. Under the shade of trees or in an open shed where there is a free air circulation is a suitable place for this purpose. When it is wished to induce sprouting, a dark, warm situation should be chosen. Frequent inspections of the seed are necessary, and any tubers showing signs of rotting or other troubles should be removed.

Rain will do no injury provided the stacks are so arranged that they will readily drain and dry off. By placing the bud ends uppermost, it tends to stimulate the development of strong sprouts which, in the presence of light, remain short and stubby, and are not easily broken off.

The benefits derived from greening and sprouting the seed before planting are quick maturity and increased yields.

The storage of marketable potatoes, to be successful, depends upon temperature, aeration, soundness of the tubers, and the exclusion of light. Layers of potatoes of not more than three feet in depth covered by straw, and where conditions are otherwise suitable, stacking reasonably high in bags, in an airy, well ventilated, but darkened shed, are sufficient in the cooler areas of the State.

In the hotter sections the practice of pitting or clamping during the summer months has met with a fair measure of success in the few instances tried, and more of this system of storage should be resorted to by growers.

Large stocks of potatoes are held in this manner every year by growers in Victoria, and our inspections of imported potatoes from that State reveal that, given reasonable freedom from disease during the growing period, the tubers arrive in excellent condition.

As production increases, and the markets fail to absorb stocks readily, the question of storage must receive earnest consideration if gluts with consequent low prices are to be avoided.

Is it essential that seed for swamp planting must be grown on the hill soils?

There is a firmly rooted idea, not without justification, that seed from the hills is more vigorous than that from lower elevations. Certainly it is true that potatoes grown under cool, moist climatic conditions are better than those grown in hot sections. Seed grown on the hills in the Great Southern districts as an autumn crop, in the cool season of the year, may equal or surpass in producing quality, that grown north of Bunbury. While climate, no doubt, has some direct effect on the vigour of seed potatoes, it has also been found that high temperatures and dryness mask the effect of certain diseases, especially mosaic, so that it is not possible to rogue out the diseased plants from the seed plots effectively where the temperatures are high, humidity low, and sunlight intense. These diseases are manifested most clearly in cooler, more humid sections.

In lower elevations with relatively high summer temperatures, the soil is apt to obtain a high temperature which becomes favourable for the development of soil-borne diseases. These diseases may in several cases destroy the crop, and in less severe cases reduce both yield and quality. The hills, to a large extent, escape the initial period for these diseases.

For autumn and spring crops where there is likely to be a fair rainfall, is it best to put on the full amount of manure when planting, or to use part for top dressing later? Is it advisable to top dress with sulphate of ammonia alone? If so, how much per acre?

The potato plant does not forage nearly so far for moisture and soil nutrients as do many other crops. The root system forms early, after the tuber sprouts. If soluble plant food is readily available within the feeding zone of these roots, there will be thrifty growth of plants from the beginning.

Field experiments at various seasons of the year have included many comparisons of different formulas, and the rate and method of application of fertilisers, including broadcasting by hand, drilling in by machinery in advance of the planting, sowing along the land side with the seed placed opposite, distributing in the furrow next following the planting row, applying half of the fertiliser in the furrow at the time of planting, and the balance as a top dressing when the plants were from three to four inches in height; the use of planter combinations and many other mechanical devices too numerous to mention.

From these experiments, and when one considers that many of our growers are experimentalists themselves, the fact that the practice still obtains with at least 80 per cent. of growers of sowing the required weight of fertiliser in the furrow at the time of planting, would point to this method as being the most satisfactory. At the same time it is recognised by not a few that crops respond profitably to a top dressing of two cwts. of sulphate of ammonia per acre, applied just as the plants are showing in the rows. Care must be exercised, however, in not allowing the chemical to come into direct contact with the plants, as otherwise burning will result.

Apparatus for dipping potatoes in the bags.

Disinfection of seed before planting is a necessary step in potato culture, aimed primarily at control of Scab and Rhizoctonia. For the proved standard treatment, corrosive sublimate is used at the rate of four ounces to 25 gallons of water. This chemical reacts with any sort of metal container, therefore, only wooden or stoneware vessels should be used in preparing the solution.

Potatoes should always be dipped before they are cut, and they should be left in the solution for one and a half hours, as a shorter treatment is not effective. Seed should be emptied from the bags. To dip in the bags is objectionable by reason of the bags absorbing the corrosive sublimate from the solution very rapidly, thus weakening it, and lessening its efficiency.

Where racks are in use a permanent cement trough could cheaply be set up convenient to the stack, and the dipping proceed with a minimum of labour. If something movable is required, a fairly stout wooden trough, "pitched" at the seams would meet the case. Construct both to size suitable to measurements of racks, and of a depth to immerse one or more racks at the time. Arrange for plug, and for safety—since corrosive sublimate is a most deadly poison. When dipping is finished, dig a hole in the ground immediately beneath the escape, allowing the unwanted solution to drain therein, and finally filling in with earth.

In those districts where seed is not racked quite a number of progressive growers have established cement troughs, and use crates adapted from suitable cases or boxes to contain their seed. Six crates are put into use, and by a system of timing two crates are placed in the dip every half hour and two removed to drain and dry. The waiting time is employed in picking over and preparing further crates of seed for dipping. This idea lends itself to extension where large quantities of seed are to be dealt with, and economises in both time and labour, besides being most effective.

THE BDELLID MITE.

(*Biscirus lapidarius Kramer.*)

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FIELD NOTES.

The Bdellid Mite first came into evidence in Western Australia in May, 1931. Reports were received from Mr. Weller of Waroona that the lucerne flea, once a serious pest on his property, was appreciably decreasing. This led to an investigation being made by Mr. H. Womersley* and the Entomologist of the Department of Agriculture, whereupon the predatory mite was discovered in large numbers.

Further investigations concerning the effect of the mite upon the flea population were carried out by Mr. G. Currie, of the C.S.I.R., during the months of July and August, 1933.

* Mr. Womersley was working under the auspices of the Commonwealth Council for Scientific and Industrial Research and in conjunction with Mr. L. J. Newman, Government Entomologist.

A detailed description of the mite and its eggs is given by Womersley (1933) and notes on its general economy. Currie (1934) gives statistical details of the effect of the mite on "flea" populations in certain localities, particularly on the properties of Messrs. Weller and Torr at Waroona.

On May 14th, 1934, the writer paid a fortnight's visit to the Roelands-Burekup area where the mite had been previously recorded. The flea was found affecting the clover in various places, but the mite exercised a definite control where it was present in numbers and various residents testified to the fact that regions then populated by the mite and relatively free from the "flea" had been heavily infested in previous seasons.

In several places examples of mites advancing on a face were noted and spots marked for future reference. Another visit was paid to the district in August, 1934, and mites and fleas were then more numerous than in May, but where the former were in force the latter were of little economic importance. On the property of Mr. Harnett, Roelands, the mites were particularly abundant, and during the sunny periods of showery days could be found crawling in hundreds like ants over fallen trees and charred logs.

In October of the same year a third visit was paid to the district, in the hopes of discovering the over-summering eggs, by means of which the mite was believed to tide over the dry weather. The mite had by then become considerably reduced in numbers owing to the intermittent warm spells which had been experienced, heralding the approach of summer. Showery weather, however, prevailed during the visit, and hatched eggs, larval mites and unhatched eggs, as well as adults, were found. A number of eggs were brought to Perth and kept under dry conditions in the laboratory until the following year.

In May and June 1935, the Roelands district was again visited and the distribution of the mite and flea examined and compared with that of the previous season. Only in isolated patches was the flea found to be making its presence felt and the mite was found in more scattered localities than the previous year, due to colonies distributed the winter before, and also owing to the natural spread of the predator. The mites, however, were not so plentiful as during August, 1934. This can be explained by two factors—the lateness of the winter rains and the scarcity of the flea, the latter of course, being largely influenced by the former.

On the property of Mr. Bower, Roelands, the mites were found advancing from one corner on to flea infested clover in May, 1934; this spot was visited and fleas and mites were very scarce, but further on the mites were more plentiful, as were also the fleas although not in serious proportions.

On Mr. Harnett's property, where the mites were thickest the previous season, they were now rather scarce, but this was probably due to the depletion of the flea population by the predator the previous year and the consequent reduction in the food supply.

BIOLOGY OF THE MITE.

It has been surmised by previous investigators that the mite survives the summer period by means of aestivating eggs, and experiments carried out with eggs obtained in October, 1934, proved this surmise to be correct.

Eggs laid upon the under side of pieces of timber were collected and kept in the laboratory in a lamp glass sealed with cellophane until the advent of the 1935 winter rains. The eggs were then moistened and kept under humid conditions for about 10 days at room temperature, when the larval mites emerged.

The aestivating eggs are apparently of the same type as the ordinary eggs, and their hatching seems to be controlled by the humidity, for, as stated in the field notes, unhatched eggs, hatched eggs and larval mites were collected in October, and among the clusters of eggs saved for the experiments many empty shells were noted. Further experiments on the development of the mite were carried out. About a dozen mites were kept in a petri dish of moist sand with leaves and bark as cover, and some twenty eggs were laid on May 2nd, 1934. These were kept, some on moist earth and some on dry blotting paper. Some of those kept on moist earth hatched on May 13th. The day following a trip had to be made to Roelands and the remaining eggs were taken in a tube but they were allowed to dry for seven days. They were then damped and allowed to dry again. On being brought back to the laboratory and placed upon moist blotting paper they continued to develop, and on June 14th one larva emerged; several others burst the egg shell but failed to make a successful exit.

Fig. I.
Cluster of Bdellid eggs laid upon bark.
(Original.)

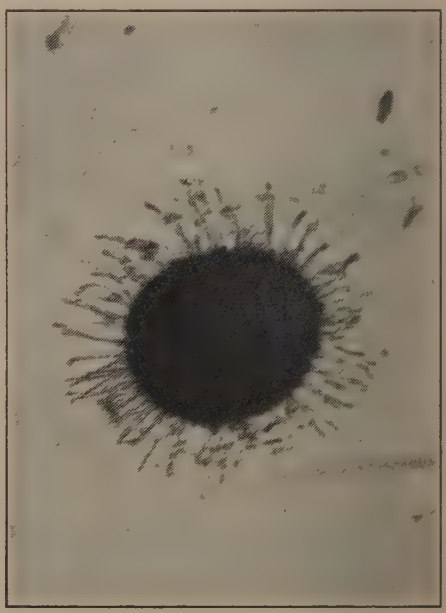

Fig. II.
Egg of Bdellid Mite (greatly enlarged).
(Original.)

On June 26th more eggs were obtained and kept in a petri dish of sand, which was alternatively moistened and then allowed to dry. Development proceeded and a number of eggs burst open, but no mites emerged until July 30th and several died within their shells.

The lengthened incubation period and mortality during development were doubtless due to the lower temperatures and the intermittent drying of the eggs.

It would appear that moisture is the chief controlling factor in egg development and that after a certain stage has been reached dry conditions are fatal.

The following table will illustrate the effect of humidity upon the incubation period:—

Date Laid or Collected.	Treatment.	Date Hatched.	Egg Stage.
2–5–34	Kept on moist earth	13–5–34	11 days
2–5–34	Kept on moist earth for 7 days, allowed to dry for 7 days and then replaced on moist earth	14–6–34	43 days
26–6–34	Kept on sand alternately moistened and allowed to dry	20–7–34	24 days
12–10–34	Kept under dry conditions until 14th April, 1935, when placed on damp sand	24–4–35	194 days

The eggs of the Bdellid are scattered singly or in clusters on the under side of fallen leaves, bark and timber, charred logs being sometimes chosen, and roughened or broken surfaces are picked for preference. Mr. Womersley reports finding eggs several feet from the ground under the bark of trees in South Australia and although no eggs have been found in such situations locally, the mites have been observed climbing tree trunks.

The eggs are small and almost round, of a brownish colour when first laid, but they bleach to a straw colour on exposure. They measure .2 mm.* by .18 mm. and are covered with clavate spines .093 mm. in length. During development the eggs swell slightly from the absorption of water and adopt a slightly pinkish hue. Finally the chorion splits and the proboscis of the mite, still enclosed in the inner membrane, protrudes. Development may remain at this stage for some hours, but in those which were under observation, after the final struggles to escape commenced the process of emergence took about thirty minutes.

The shells split and the larvae gradually forced their way out, but no lid-like operculum lifted off. The first appendages to become free were the palps; these were armed with two long spines which were used to comb and apparently clean the limbs as they were dragged free in order of rotation. Soon after emerging the tiny creatures were actively running over the slide testing the surface with their palps, which serve a sensory function.

Attempts to rear the larvae have up to the present met with little success as the creatures are so very tiny and delicate on emerging from the eggs that the feeding question is a problem, and moisture, although essential to their well being, frequently causes casualties, damp blotting paper even being responsible for the death of several individuals.

In order to find out the number of eggs laid by an individual mite, several were isolated in tubes sealed at one end with cellophane and plugged at the other with moist sphagnum wrapped in cellophane. A small piece of bark was included for laying purposes. About 20 eggs was the average obtained, although this may not be a true guide to the number naturally laid, owing to the artificial conditions and reduced food supply. However, several females, on dissection revealed about this number of almost mature eggs. One female contained what appeared to be about 100 immature eggs, which would suggest that several batches of eggs are laid by an individual before death.

* 1/125th inch approximately.

As noted by Womersley (1933) the mites were found to be more or less gregarious at certain periods, specimens being observed clustered together on bark beneath the shelter of spiders' webs. During this stage the mites appear to be quite dead and may remain in this state for two days. This dormancy is apparently associated with ecdysis, as moulted skins are always to be found in the vicinity.

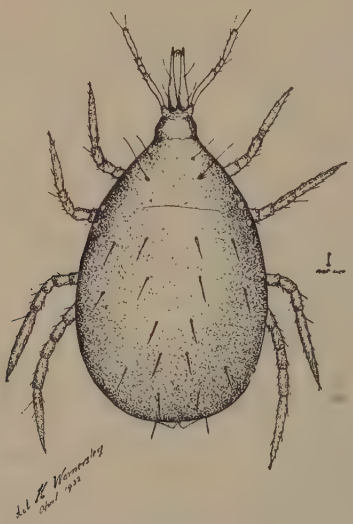

Fig. III.
Lucerne Flea Predator (*Biscirus lapidarius*).

FEEDING HABITS.

Bdellids were kept in a petri dish of moist earth and litter sealed with cellophane for 16 days, during which period egg laying took place. Lucerne fleas and various other small collembola and psochids were supplied as food.

Womersley and Currie both refer to the ability of the mites to subsist on insects other than lucerne fleas; however, it is interesting to note that Currie says "In the field the mites were never found feeding on a prey other than lucerne fleas," as on several occasions the writer has observed them sucking other small insects, apparently psochids. Moisture is very essential to the adult mites and specimens kept for a day under dry conditions and without food immediately commenced to suck water from a piece of damp bark subsequently introduced into the tube.

Further experiments were tried to confirm Currie's opinion that the eggs of the Lucerne Flea are not palatable to the mite. Currie writes:—"It was desired to ascertain if the mite would attack the eggs of *Sminthuris viridis*. Eggs were obtained by keeping *Sminthuris* in a petri dish on leaves of *Cryptostemma* (Cape weed). Mites were then placed in the dishes with these. At first the mites were seen to react in some measure to the presence of the eggs, running excitedly over them, but no attempt was made to suck them and the mites died in three days without attempting to feed on them."

Bdellids were kept in a petri dish with a few fleas and flea eggs and after eating the fleas the mites finally died and the flea eggs hatched safely.

In the field the Bdellids attack the fleas in any situation, as the predators may be seen sucking their prey either on the ground, beneath the shelter of a stick or piece of bark, or perched on the upper surface of a clover leaf.

SUMMARY.

(1) The mite appears to be controlling the flea in those portions of the State in which it has become firmly established.

(2) The mite survives the summer by means of aestivating eggs.

(3) The hatching of the eggs is controlled by moisture and temperature, the former being essential and the latter influencing the time necesary for development.

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SOME POINTS FOR TURKEY FARMERS.

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The raising of turkeys is generally considered to be more or less a difficult process.

This short article will endeavour to point out the pitfalls and the means of overcoming them.

Given good breeding stock, good clean land and average management, turkey raising should be a profitable line on many farms. There is little labour required and turkeys are always in demand on the Western Australian market.

VARIETIES.

The two main varieties of turkeys are the bronzewing and white.

The bronze, as its name signifies, is of a rich bronze colour, the female of the species being duller in sheen than the male. This species is the largest in size of all turkeys, ranging between 12 to 34 lbs. according to sex. While a large size is desirable to a reasonable extent the great demand is for a medium size bird, between 12 to 24 lbs.

The white turkey is pure white and the shanks should be pinkish in colour. It is supposed to have originated from sports of other varieties. They are smaller in size and generally more delicate because of unnatural breeding. The weights range between 10 to 20 lbs. according to sex.

BREEDING STOCK.

When choosing the breeding stock great care must be given to selecting turkeys having vigour, vitality and proper body formation. Vitality and vigour are of prime importance. Size does not always indicate those two qualities. Rich-coloured plumage is an evidence of vitality and loss in richness of colour is the first sign of failing vitality.

The size of the shanks in both sexes is also a strong indication of vitality. The abundance of heavy bone formation in the shank is an evidence of proper feeding with proper assimilation that can only be accomplished by a bird having inherited strength and vitality.

A male or female which has strong thick shanks and is in perfect health at from 12 months to 2 years is the bird to select in order to produce progeny having vitality and vigour and easily rearable qualities.

Turkeys that lack vitality will, when killed, have a carcase that lacks meat at the thighs and neck, the body will be long and narrow between the thighs, and the rump pointed and narrow.

The best results can never be expected from turkeys which are unusually large. It is the medium sized bird rich in vigour and vitality that can produce satisfactory progeny. The male should weigh from 20 to 24 lbs., while the female should scale 16 to 18 lbs. The male bird should be no less than twelve months of age and the female between 18 months and 3 years.

In white turkeys the weights should be a few pounds lighter than the above weights.

Select one variety and stick to it. The advantage is gained of having a thorough concentration on that variety instead of being obliged to consider others at the same time. It also ensures that the stock will ke kept pure.

BODY CONFORMATION.

Compactness should be the main aim, and flocks should be mated to perpetuate that characteristic.

A broad body—deep between the thighs—a broad long back, short thighs and heavily meated, shanks rather short and strong of bone, neck of medium length and a well developed head with prominent eyes. Besides being the desirable factors for breeding, the foregoing ensure birds, when well fed to maturity, carrying plenty of meat and resulting in a good demand at sales.

EXERCISE.

Turkeys prefer unlimited ranging but can be reared successfully in an enclosed orchard or similar field. When enclosing turkeys, the fence must be fairly high as they are fine flyers. If it is necessary to enclose on limited areas, the top should be covered in with netting and care taken not to pen too many turkeys together. Again, one wing may be clipped in order to restrict flying.

Turkeys should not be run with fowls or ducks. Such mingling is detrimental to the health of the turkeys.

ROOSTING.

Turkeys that live in the open may roost in trees and should there be any chance of damage by foxes or dogs when trees are not available, erect roosts high up from the ground. Sometimes it is desirable to build outdoor roosting places and teach the turkeys to roost by feeding close to the perching place night and morning. For young stock which cannot fly, assist with a ladder but take away the ladder after they have gone to roost in order to prevent animals from attacking the birds at night.

BREEDING.

Gobblers are best in their second year. Keep the spurs trimmed close. Mate one gobbler to any number of hens from 5 to 15. It all depends on the vitality of the gobbler. They have a tendency to become lazy as the season develops and should be watched closely. It is always advisable to have another gobbler on hand should the head of the pen become lazy or an accident or sickness impair him. The gobbler has the bigger influence on the progeny.

Maintain the vitality of the stock by the introduction of new blood yearly from farms of know cleanliness, or by the continual selection of the best of the progeny as future breeders. Selection is best done amongst the female turkeys.

If new blood is introduced by means of eggs for hatching, select the eggs from those breeders who have overcome the troubles of turkey raising and assure yourself that the eggs are from 2 or 3-year old turkey hens. Do not trade gobblers with your neighbours. You are not sure of getting new blood.

FEEDING OF BREEDING STOCK.

Wheatmeal and bran with a little meatmeal (5 per cent.) and bonemeal (2½ per cent. by weight) is an ideal ration as a mash for stock, but whole wheat may be given during the day and at evening meal.

After harvest less wheat is required if the birds have free range, but one must supply plenty of green feed at all times.

Shell-grit, stone-grit and bonemeal are absolutely necessary in turkey feeding.

Plenty of fresh water is required daily and sweet milk is an asset if available.

Any putrid or sour food is detrimental to the birds.

Feed the soft food in troughs, but not on the ground.

Generally speaking, one visit by the male will fertilise a setting of eggs.

Turkeys will lay from 12 to 15 eggs before becoming broody. Eggs can be incubated artificially or naturally; the natural method is preferable. Entice the hens to lay near home by making heaps of bushes about the yards. They desire a quiet setting and should not be disturbed.

Turkey eggs take 28 days to hatch. The freshness of the egg has a marked effect on the punctuality of the hatch and to that end only fresh eggs should be set. Each hen should have only as many eggs as she can cover comfortably.

Strict attention to the hen during her sitting period is necessary. It may be advisable to help her from the nest should she decline to leave for feeding purposes. Never feed her on the nest, but fresh water should always be close handy.

BROODING.

Leave the poults with the hens. Turkey hens that have previously reared a brood are more attentive to the youngsters than young hens with their first family. Poults thrive if one gives them the same attention as one would give chicks. Most of the troubles develop through lack of attention during the early stages of growth.

Sanitary conditions in the coop are most desirable; no dampness, no draughts and no excessively warm quarters. They thrive better under cool conditions.

Keep the ground round the coops ploughed or harrowed and do not allow the direct rays of the sun to fall on the poults for any length of time. Neglect of both these precautions is dangerous.

Parasites are treacherous. Do not let lice or other external vermin get a hold —prevent rather than cure. Insect powders must be liberally applied, and keep poults of different ages apart until the young ones are strong.

FEEDING OF POULTS.

Let the young poults pick at some fine shell-grit at first and then give them a meal of soft boiled egg mixed with a little stale bread. This is an excellent starter. Then feed on a mash of chopped-up greens with 3 parts of wheatmeal to 5 parts of bran, ½ part of meatmeal and a little bonemeal. Chopped onion tops are excellent and if obtainable should be fed.

It is vital that the meatmeal and bonemeal be given to all young growing stock. These two ingredients are the main bone and body builders.

Cracked wheat is also fed during the day—little and often with turkeys. Do not let them over-eat.

When the poults begin to look after themselves their meals can be less frequent, for in their wanderings they will find a fair quantity of feed.

Take care that the food is neither wet nor sloppy. Give as much sweet milk as possible but take care it does not sour.

Cooked lean meat is another important manner of feeding the meatmeal ration.

At about 10 weeks, when they have "shot the red," the poults are over the dangerous stage of growth and should thrive if fed sufficiently on good wholesome diet. Keep grit, shell-grit and charcoal available at all times.

As turkeys are bred for flesh, good bone and body are essential in order for them to carry plenty of meat. When the frame is strong and large the birds can be fed up to marketing condition. To feed a fattening ration lower the proportion of meatmeal and bonemeal.

CRATING FOR MARKET.

Care must be taken to ensure that the birds have sufficient head room in the crates when being forwarded to market. Too many birds are damaged on arrival owing to overcrowding in unsuitable crates. The crates should be tall enough to allow the birds the privilege of standing upright, and do not try to force too many into a small crate. Comfort during a journey is a small premium to ensure that your birds arrive at the market in the best of condition.

DISEASES.

All diseases troubling the domestic fowl may affect turkeys. Under our ideal conditions prevention is better than the cure. By strict attention to management throughout the life of the bird, one can be fairly safe from serious trouble. Cleanliness, open air, good food, and clean cool water are the first principles to be applied.

Turkeys should never be allowed to run with other domestic fowls. Keep them strictly by themselves.

VITAMIN "A" DEFICIENCY.

This vitamin is present in practically all green feeds, so that if plenty of grass is available no trouble should be experienced. When green feed is not available, and such is the condition in most of the country districts during the summer period, trouble may occur.

The symptoms of vitamin "A" deficiency are quite pronounced. First there is a watery discharge from the eyes and nose similar to catarrh, followed by a deposit within the eye which can easily be removed. In the mouth and throat will be found small round nodules projecting within the mucous membranes. Emaciation follows and the bird weakens and finally dies.

Its characteristic in comparison to roup is that it does not emit an offensive odour, and the deposit in the eyes is of a greyish colour. The presence of the nodules in the digestive tract are also definite.

Two per cent. of cod liver oil in the ration will prevent this disease.

Should the farmer at any time be short in green feed supplies, it is always advisable to use cod liver oil.

VITAMIN "D" DEFICIENCY.

Vitamin "D" is present in most green foods, cod liver oil and a variety of other foods. This deficiency causes rickets and leg weakness. It is a common complaint with young stock which have been kept in enclosed sheds. Sunlight is a source of supply of this vitamin, therefore see that young stock have access to the health-giving rays of the sunlight, besides feeding plenty of green feed.

MINERAL DEFICIENCY.

While several minerals are necessary for the growth of a bird, the most common deficiency is calcium. Insufficient supply of easily assimilated lime will cause leg weakness, poor bone formation, crooked breasts and mis-shapen bones.

Stress must be laid on the necessity of having available a plentiful supply of bone-forming material. No bird can make strong bone unless it is supplied in the ration.

Turkeys, which are naturally big-boned birds, require a continuous supply of calcium during the growing periods. It is no uncommon sight to see birds with twisted legs and weak ribs and breastbones, due to the farmer not realising the necessity of adding bone-forming meats to the feed.

Wheat is a good food, but wheat alone will not grow turkeys. We must realise that turkey farming needs as much, if not more, care as other poultry and they must be fed a ration containing meatmeal and bonemeal.

INFECTIOUS DISEASES.

Catarrh.—Catarrh is caused through draughts or exposure to cold and wet. The birds are dull in appearance, have mucus running from the nostrils and breathe through the mouth, the eyes are watery and the bird has a listless appearance. (See this Journal, December, 1934.)

Chicken Pox.—Chicken pox shows up as warts on the unfeathered parts of the head and comb. They are little round nodules to start with and they gradually grow. Those round the eyes will eventually cover the eyes and close them, causing blindness. The bird then starves and dies.

Treat the affected parts with zinc ointment made as follows:—Obtain six-pennyworth of oxide of zinc; the same bulk in flowers of sulphur; mix together with olive oil and lard to a creamy paste. This ointment applied to the affected part of the bird, which will be the eye in this case, is a proved remedy.

Should the birds be "running" at the nose, the disease has got a deeper hold. If the bird is worth keeping, syringe the nostrils out with peroxide of hydrogen, using an eye dropper but making extreme pressure when syringing. This will clear out the nostril. The next stage will be "running" eye and cankerous growth in the mouth. At this stage it is hardly worth while persevering with individual birds. These birds may be eaten; it would pay to kill them all, but they may be treated.

Diphtheritic Roup.—Lift the cankerous growth with a sharp stick and paint the affected spot with perchloride of iron, taking care that none drops down the throat. Sometimes the cankerous growth is in the windpipe. The pipe must be cleared. This is done with a pointed stick, the bird coughing extensively during the operation. Bleeding must be avoided, and by painting with perchloride of iron the disease will be arrested.

Any eye trouble should be treated by placing one drop of 10 per cent. argyrol in each eye, night and morning.

Roup.—Roup affects the birds during changeable weather. Farmers are advised to treat the water with permanganate of potash to the colour of a deep claret and at the same time putting enough kerosene on top of the water to wholly cover it with a film. The permanganate internally helps the bird, and the kerosene on the top kills the germ which is left there by a sick fowl when drinking.

Roup is a dangerous disease and may make its presence felt in many forms. It may be seen as eye roup, contagious catarrh, diphtheria and canker. It is caused through colds, draughts and breathing foul air. It is a good plan to consider chicken pox and catarrh as the forerunner of some roupy ailment and treat immediately for it.

The zinc ointment for chicken pox will clear up that ailment. One may find that canker has formed in the mouth. We are then on the journey to deep-seated troubles and must make more drastic moves to cope with the disease. Roup is always distinguished by the extremely foul odour which passes with the breathing of an affected bird and can be diagnosed before any outward symptoms are sighted.

The peculiar odour, once recognised, is easily noticed on entering a shed at night should that shed contain affected birds. It can also be noticed when handling an affected bird. On recognising the odour, take steps to cope with the trouble. See that the sheds have plenty of ventilation without draughts. Keep everything clean and doctor the water as before mentioned. Burn all fowls dying of this trouble.

"Blackhead" (Enterohepatitis).—Of all the diseases troubling turkeys this is the worst. One cannot diagnose it with confidence until death allows of a post-mortem. The name "Blackhead" is not significant because in any wasting disease the head goes black just before death.

Enterohepatitis defines that both the intestines and liver are affected.

The disease is caused by a protozoan parasite but this parasite is not essential in the transmission of the disease. Although blackhead affects turkeys of all ages it is fatal to young stock. The mortality in birds up to 3 months of age is very high.

Dullness, separation from the flock, sulphur-coloured diarrhoea, and drooping wings are the marked symptoms displayed, and the birds live only a few days after showing those symptoms.

It is advisable to post-mortem all birds that die from an unknown cause. Place the bird to be opened on a table, breast upwards. Cut off both legs and clean the skin with the feathers from the breast bone. Insert the operating knife between the last rib and the breast bone and cut towards the neck. Do this both sides of the bird. Pressure on the breast bone, forcing it upwards and backwards, will break the bone near the neck and expose the whole of the inside of the bird. Care must be taken to ensure that no damage is done by cutting the internal organs while preparing the carcase for internal exposure.

Circle the vent with the operating instrument, taking extreme care not to damage the intestines, and carefully untangle the intestines and withdraw carefully until the whole is laid out clearly beside the bird.

On examining the intestines upward from the vent, one will find two blind branches to the intestines running in a downward direction. These blind branches are called the "caeca."

Examine the liver. This will show ring-shaped areas spotted over the surface with enlargement of that organ. The caeca will be swollen with a yellowish cheesy matter. One or both of the blind guts will be affected.

The liver simulates tuberculosis to some degree, but in tuberculosis the spots are smaller and may project above the surface. The caeca is seldom affected by tuberculosis.

No treatment so far has been found to be really efficient.

One might try 1 teaspoonful of Ipecac powder mixed in the mash to each 10 birds. Ipecac has been recommended as a possible preventive by feeding to the flock weekly.

One part bichloride of mercury to 10,000 parts water as a drinking water has also been reported as effective. If bichloride of mercury is used it must be understood that it is highly poisonous to man and will discolour metal vessels.

Prevention is the better means of control. Two per cent. tobacco dust weekly (in the mash) will help.

Prevention.—It has been found that there is a close resemblance between blackhead and the caecum worm in fowls—demonstrating the wisdom of not allowing turkeys access to buildings or land in which chickens have been reared.

Sanitation is the key to prevention.

Puffed Sinus.—The symptoms are fairly well known. They consist of a swelling or puffy condition of the face due to the swelling of the sinus below the eye. This is caused by being clogged with a mucus. Pressure applied to the affected parts will usually empty the sinus into the nasal cavity but they will again fill.

Open the sinus and inject 10 per cent. argyrol, but a still better method, and one which has met with great success, is to inject 10 per cent. argyrol with a hypodermic needle into the sinus. A second or third injection may be needed.

At times the sinus hardens to a cheesy mass which will "head" inside the roof of the mouth. This can be cleared with a match and then syringed with perchloride of iron or argyrol.

Coccidiosis.—Coccidiosis is one of the worst diseases with which the industry has to cope, especially in chicks. If coccidia are present in young stock, mortality will reach as high as 70 per cent. to 80 per cent. The disease spreads rapidly and

those surviving birds receive such a setback that they can never be profitable. Hence the advice to "kill off" all which are affected or are in contact with diseased stock.

Coccidiosis is due to a parasite (*Ermeria coccidium*). The droppings of affected fowls contain enormous quantities of "cocysts" as the parasite is known at this stage. It is here very resistant to disinfectants and can live in subsoil for 12 months or more. The cocyst resembles a miniature egg which in moisture and warmth "hatches" or sporulates into four smaller elements or primary infective germs. This period takes at least 48 hours and it is during this time that disinfectant measures, which are described below, are most effective.

This phase of the disease is the important basis of control. The unsporulated cocyst, if swallowed, will not produce coccidiosis and the severity of the disease is due entirely to the number of primary infective germs present and consumed, due to contamination of feed, water and soil. These infective germs are swallowed by the bird, journey to the intestines, and are there broken down by the intestinal juices into other elements which attack the walls of the intestines,, grow and multiply and destroy these walls. Other forms now appear with further subdivision and, finally, a fertilised female "the cocyst" is passed out in the droppings. So much for a rough idea of the life cycle of the germ which causes coccidiosis.

Unfortunately, little can be done to check the ravages inside the chicken. We must concentrate on outside influences to cope with the trouble.

The disease is encountered in chickens of all ages, but is more pronounced after three weeks until ten weeks of age.

Symptoms.—Suspect coccidiosis when diarrhoea begins to make its appearance and do not delay in obtaining expert advice. A microscopical examination is necessary to confirm any suspicion of the presence of coccidia.

Acute diarrhoea, with or without blood in the droppings, thirst, wasting away and the chicks appearing listless and unthrifty are the symptoms.

On post mortem examination the caeca or blind gut is usually enlarged and may or may not contain blood-stained material.

On the appearance of diarrhoea with presence of blood in chicks over a fortnight old, suspect coccidiosis.

Control.—By sanitation and by internal treatments.

Sanitation.—Remove the droppings daily and burn. Heat will kill the cocysts.

The use of lime on the floors keeps the birds from being contaminated from their droppings which have fallen through the wire.

Keep shifting the birds to new ground if the houses have no floors with which to control the trouble. Sunlight is a control.

Ground once infested should not be used for a period of twelve months.

Treatment.—Kerr's treatment below is of great importance and has been found the most effective:—

Make a solution of iodine crystals, 1 part by weight, potassium iodide 2 parts, water 50 parts. To a quart of fresh or separated milk add 3 oz. of the above iodine solution, and heat in any vessel until it becomes white. This is the stock solution and one pint should be added to every gallon of the drinking water used. This method of treatment, in conjunction with the use of the flame of a painter's blow-lamp on the brooder and on the brooder house floors, has an immediate effect on the death rate.

B.W.D. is an abbreviation of the words bacillary white diarrhoea, now known as Pullorum disease, a quite separate disease from coccidiosis.

BEE HIVES.

H. Willoughby Lance, Apiculturist.

The efficiency of the honey bee depends very largely on being housed in a suitable hive, which can be and is efficiently handled by the apiarist in a practical manner.

In the first place, any other home for bees except the moveable frame type is neither efficient nor suitable.

(a) They cannot be properly examined for disease nor for any other purpose.

(b) The combs cannot be moved about in the hive to induce or retard breeding, nor can they be added to to provide room for brood or honey. In other words, they cannot be managed.

(c) The surplus store of honey cannot be removed without cutting and breaking the combs.

Primarily, for the first reason "The Bees Act, 1930," provides that all bees must be kept in frame hives which are in good condition, from which any one comb can be removed for inspection without cutting or breaking.

In the second place, such moveable frame hive should be of a type or pattern suitable to the weather conditions and climate of the country where they are used; also for the honey flow of the particular district. Some districts with a short heavy honey flow may require large hives with large frames; others with a medium spread-out flow, smaller frames or hives.

In the third place all hives in an apiary should be of one standard pattern and size to facilitate their interchange and use. It is also advisable that they should be of a standard pattern mostly in use in the country, so that if other hives are purchased they may be interchangeable, and if sold they will fetch a better price than an odd size or pattern.

A very great variety of types and sizes of hives have been and are still used in the different countries of the world. Generally speaking, there are two types of hives; the double walled and single walled types. There are also two ways of arranging the frames in the hives. One with the frames parallel to the entrance, commonly called "warm way," and another with the frames at right angles to the entrance, called "cold way."

The majority of hives are made to take the frames cold way, but a few bee-keepers prefer the warm may. From tests made there does not appear to be very much difference in the efficiency of either method, but the great majority of bee-keepers prefer the cold way, particularly in hot climates, as this allows a freer circulation of air through the combs. When bees build their combs in trees, etc., in the natural state, there is no set rule as to which way the combs run; they are found in all directions, showing that from the bees' point of view, one way is as good as another.

In the hives described hereunder, the combs are arranged cold way, but if anyone prefers the warm way, it is easy to arrange for the entrance to be at what is called the side of the hive instead of at the end.

DOUBLE WALLED HIVES.

The double walled hive is used very largely in Great Britain, as this type enables packing to be placed between the walls during the cold winter weather. This is removed during the summer and allows a draught of air to pass between the

walls to keep the hive cool. As very little migratory bee-keeping is practised in England, these hives are most suitable. It is also used in some parts of America, but it is not suitable for countries or districts where the hives are frequently moved from one district to another. In this country it is not used by commercial bee-keepers on account of their frequent movements to follow the honey flow, and the extra cost. It is, however, a most suitable hive where bees are kept at a fixed location, as the space between the walls keeps the hive much cooler and bees do not hang outside and loaf unless very much overcrowded.

The double walled hive is practically a standard sized hive inside a larger one, with a space of about one inch between the walls of the two hives. The bodies are made of ½-inch thick wood instead of ⅞-inch. A quilt, or preferably a wooden cover board or ceiling is laid on top of the inner hive, while a gable or sloping roof fits over the outer one, there being a space of two or three inches between the ceiling and the roof.

Figure 1 shows a "W B C" double-wall hive with gable roof. Figure 2 shows section of similar hive with sloping roof.

Fig. 1.

These hives are fitted with a good sloping landing board, a good porch to prevent rain running down to the entrance and driving in; also with slides to enlarge or contract the entrance. These are all excellent points and may easily be fitted to the standard factory made Langstroth hive if used in a home apiary and not moved about on carts or trucks, as in that case, they would be liable to damage.

SINGLE WALL HIVES.

The type of single wall hive in general use in America and Australia is the Langstroth hive, made to take frames 17⅜ inches long. There are two standard sizes, one to take eight frames and one 10 frames.

There are three different heights of frame in general use, the box portion being made to suit the depth. The standard Langstroth is 9¼ inches high; the W.S.P., or three-quarter depth, is 7¼ inches high; the Bolton or Ideal is 5⅜ inches.

The hive in almost general use is the ten frame with Standard frame 9⅛ inches high. These, however, are rather heavy to lift when filled with honey and the eight frame Standard or the 10 frame W.S.P. is much easier for working by women or persons who are not strong. In the majority of cases, however, the 10 frame standard Langstroth will be found to give the best results.

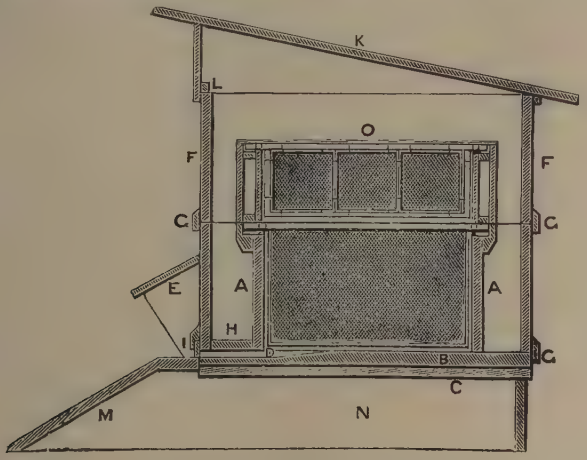


Fig. 2.

FACTORY-MADE SINGLE WALL HIVES.

Figure 3 shows a 10-frame factory-made hive of Langstroth pattern with flat cover. Note the dove-tailing of the corners, which makes a thoroughly strong job. These are supplied in the flat and put together by the bee-keeper. Joints should be painted, and nailed at every dove-tail with 2¼-inch cement-coated nails. These hives can be obtained in either the 8-frame or 10-frame size.

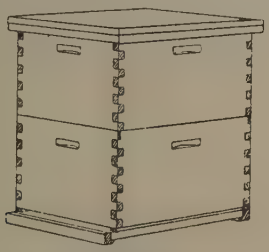


Fig. 3.

In this hive the tops of the frames are ¼ inch below the top of the body, allowing a bee space over the frames. The bottoms of the frames are flush with the bottom of the body, the bee space and entrance being obtained by ⅜-inch strips on the floor along the sides and back. With this method the bodies can be used either as brood chambers or supers, and is much to be preferred to hives with fixed floors.

Supers for standard Langstroth hives, whether home-made or factory-made, may either be full depth 9½ inches, W.S.P. 7½ inches, Ideal 5¾ inches, or half-depth 4¾ inches, according to the requirements of the district or one's personal

preference. The drawback with the W.S.P. and Ideal size is that ordinary extractors made to take the full-depth frame will not take two Ideals; whereas it will take two half-depth frames.

A few bee-keepers prefer the Bolton hive. This hive has frames the same length as the Langstroth, but 5⅜ inches deep, that is the same size as for supers. The hive was designed by Mr. Bolton for a special system to prevent swarming, which cannot be gone into here. Brood chambers and supers are all the same size, and the bodies are fitted with thumb-screws at the sides to tighten the frames together, thus allowing the bodies to be reversed. It can, however, be used as an ordinary hive, without working on the Bolton system, by using one, two or three bodies for brood, as may be required.

Covers for Roofs.

Many types of covers are in use by bee-keepers. Some use flat, thick wood covers, but these do not weather well and they do not run off the rain.

The Beuhne cover is made of thin wood, covered with a sheet metal roof, packed with newspapers between the wood and metal.

The Ventilated Gable Cover has a wood ceiling and a wooden gable roof, with an air space between the two. One drawback about this cover is that it is a harbour for spiders which, on account of its gable design, are difficult to dislodge; also, the roof being of wood is liable, unless painted frequently, to weather badly and crack.

A cheap and efficient cover is that illustrated in Figure 4. It has proved most satisfactory for Western Australian conditions and is very easy to make. The important thing is to get dried and seasoned wood, so that it does not shrink and allow an entrance for robbers at the joints.

The use of quilts is not recommended, as these rest on the top of the frames and prevent the bees from passing over them. The bees, therefore, stick them to the frames with propolis. Quilts are a harbour for moth grubs, as the bees, however strong, cannot get at them. I am a strong believer in a bee space of ¼ inch to ⅜ inch between the tops of frames and the ceiling.

I occasionally find old-fashioned hives with the gable type of roof and no ceiling or quilt. The great drawback of this type is that there is a space of several inches between the tops of frames and the roof, which the bees frequently fill with comb and honey. When the bee-keeper lifts the cover the comb is broken and there is a lovely mess of honey running down into the hive and drowning hundreds of bees. The difficulty with these covers can be overcome by making a loose ceiling to rest on the top of the hive; the roof can be placed on this and the air space between the ceiling and roof will keep the hive cool.

Floor Boards.

With factory-made hives, these are always separate from the body, and I strongly recommend that they should always be kept so, as it is necessary that they should be kept clean. At periods when there is a dearth of nectar, the bees uncap their sealed stores for food and the cappings fall to the floor. This is specially noticeable at the close of winter, and the refuse is a fine breeding-place for moth-grubs. A sprightly moth may dodge the entrance guards and just have time to deposit a few eggs in the refuse before the inhabitants are aware of her presence. If the refuse is thick or the frames too close to the floor, the bees cannot get at the grubs to destroy them and it may be the beginning of the end of the colony.

Manufacturers usually supply bottom boards about ⅞ inch thick, but they only project a short distance in front of the hive, and many bees coming home heavily loaded, especially in windy weather, miss this narrow alighting board and

fall to the ground; then, if there are meat ants about, it is good-bye to the Mistress Bee, but even if there are no ants, the bee will require a considerable rest before making another attempt to reach her front door. I consider that the alighting board should be about 6 inches wide and sloped to run the rain off.

To those who have factory-made floors I recommend that they should cut these off flush with the front of the hive body, nail them to two strips of 3in. x 1in. jarrah and fit a detachable alighting board, as shown in Figure 8 or Figure 9; or a permanent alighting board, as shown in Fig. 4.

HOME-MADE HIVES.

Some bee-keepers make their own hives after the Langstroth pattern from petrol cases, but in very many cases these are not satisfactory, either from lack of knowledge of the requirements of a hive, or from indifferent workmanship. The half-inch wood of petrol cases is not sufficient; two thicknesses should be used. A strip of wood nailed on the inside of the ends instead of rabbeting, is not satisfactory, as it leaves space for the building of comb. All joints, especially those of hives made from petrol cases, should be painted before being nailed together.

For the benefit of those who wish to make their own hives the following particulars are given:—

The standard sizes of factory hives are 8 and 10-frame. The petrol case will make a good 9-frame hive.

Boxes.

The inside width of an 8-frame hive is 12⅛ inches, that of a 10-frame 14¼. A petrol case will make a hive 13¾. Standard frames are 1⅜ inches wide; 10 of these would equal 13¾ inches and be a tight fit, and be very difficult to manipulate.

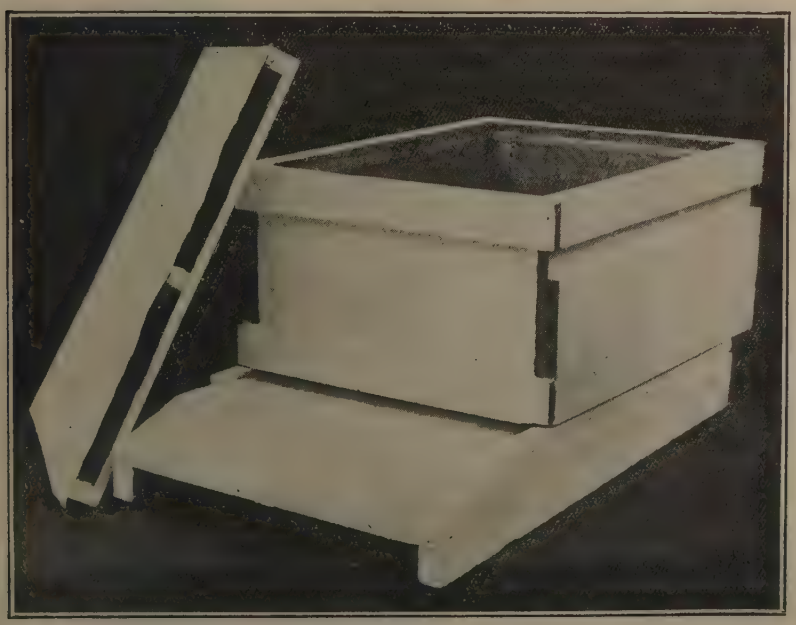
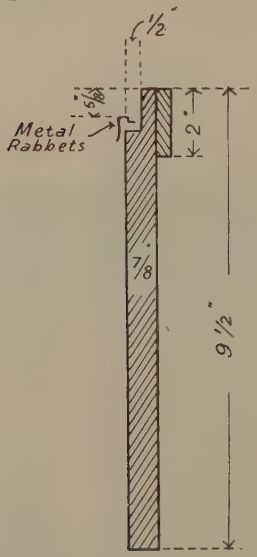


Fig. 4.

These hives, therefore, should only be used for 9-frames. In the supers these frames can be spaced out equally and should produce good fat combs easy to uncap, but in the brood chamber they should be placed close together and a dummy board, say of 7/8-inch wood, inserted to take up the extra space. The reason for this is that the natural spacing of brood combs is 1 3/8 inches. Drone brood requires a larger space, and if combs are further apart, the bees have greater facilities and inducements to build drone comb.

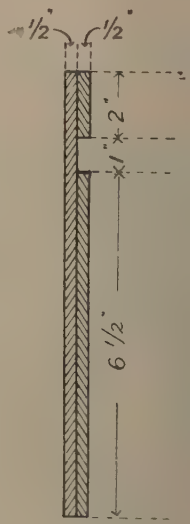
Figure 4 is a photograph of the complete hive shown with the body drawn back a little and the roof at the side. The floor is made of the sides of a petrol case half-inch thick, but if thicker wood is obtainable, so much the better. These are cut 15 3/4 inches long, nailed to two pieces of 3 x 1 jarrah, and sloped off at front to allow of a goood alighting board for the bees. The length of the level portion should be at least 23 inches. On this surface, along the back and the two sides, nail strips of wood 1in. x 3/8in. for the body to rest on. This will raise it above the floor and allow an entrance all along the front.

For the body, use the two ends of the case, the top edge being rabbeted, as shown in Figure 5, and metal rabbets nailed on. These can be obtained from any dealer in bee goods; the object of the rabbets being to allow of bees running under the ends of the frames, and also giving less surface for the bees to stick tight with propolis.



Section through AB

Fig. 5.



Section through CD

Fig. 6.

The sides of the cases are next cut 20 1/8 inches long and nailed on to the two ends. The ends are now 7/8-inch thick and the sides half-inch: half-inch, however, is thin for the sides and does not conserve the heat of the hive as well as 7/8-inch; therefore, nail another thickness of half-inch wood outside this, but not the whole depth of side. The top strip may be 2 inches wide. Then leave a 1-inch gap; the bottom strip will then be 6 1/2 inches wide. Now nail along the top and bottom of front and back two more 2-inch strips. These will strengthen the joints and the

strips along the top will give a good hold all round for lifting the body. To make the method of putting the hive together more plain, the ends of the wood in Figure 4 are shown dark. Figure 5 shows a section through the ends, and Figure 6 through the sides. Figure 7 is a plan. The inside measurements of this hive are 9½ inches high x 18⅛ inches x 13¾ inches.

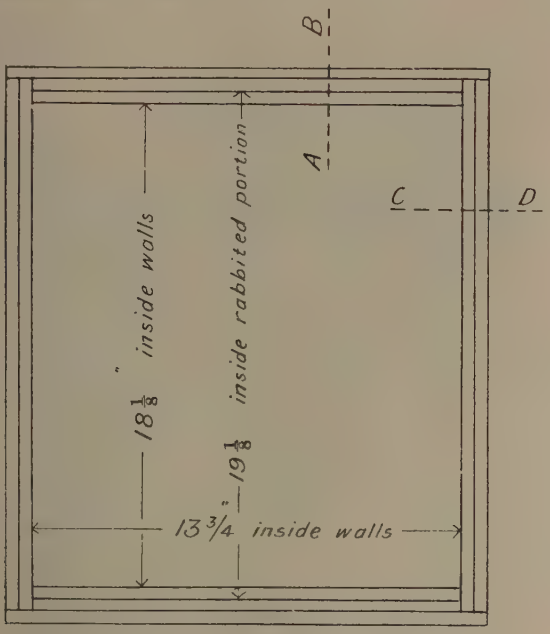


Fig. 7.

Roofs.

The roof can be made of half-inch wood from petrol cases, or, if available, thicker wood for preference. The side of a petrol case is the exact length required. Now prepare three strips of 1-inch seasoned jarrah or good white wood, 1½ inch, 1¾ inch, and 2 inches wide respectively. These form the cross pieces to which the roof is nailed, the 2-inch piece in front and the 1½-inch piece at back, thus giving a slight slope to run the water off.

A piece of galvanised iron, 25½ inches x 19 inches, is now obtained, the corners cut and the front and back bent over and nailed to the cover. The sides are bent at an angle of about 45 degrees, but not nailed. This will allow ventilation between the wood top and the iron roof, and will at the same time prevent the rain driving under. Should spiders make their web in this space, it is an easy matter to bend the sides up and clean out the web with a stick. In Figure 3 the visible side is shown bent up for cleaning.

If galvanised iron is not available, a petrol tin may be used. Cut the ends out, cut the remainder down at two opposite corners, so that you have two pieces each composed of two sides of the tin.

These may now be used for the roof, one overlapping the other; the joint being nailed down along the centre cross-piece. The whole should now be painted with two coats of paint, but if tar is available it is preferable to dip in or paint the floor board with hot tar. The iron roof may be painted with red oxide if desired.

Floor Boards.

The projecting alighting board, shown in Figure 4, is not suitable for those who move their bees about to catch the honey flow. Figures 8 and 9 show two types of detachable alighting boards.

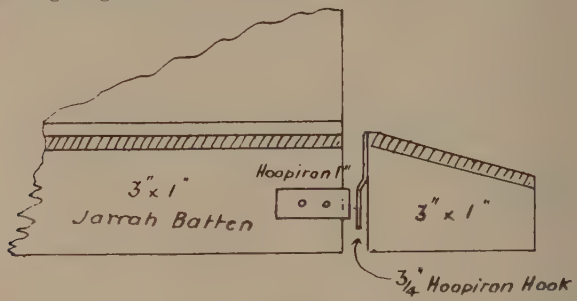


Fig. 8.

In Figure 8 the floor is cut off flush with the front of the hive body and the two clips, made of 1-inch hoop-iron, nailed to the front of the 3 x 1 jarrah battens, with the top edge $1\frac{1}{2}$ inches in from the floor. The alighting board has two strips of ½-inch hoop-iron nailed to its battens, being bent slightly so that they will just enter the clips like hooks.

Figure 9 shows the alighting board attached by dowels. Where a number of hives are in use, a jig should be made and the holes bored to the jig so as to make the boards interchangeable. The holes in the alighting board must be made a tight fit, while those in the floor are a loose fit. The dowels should be painted to prevent the absorption of water and the swelling of the wood, which might cause too tight a fit. I have both types in use and prefer the dowel type.

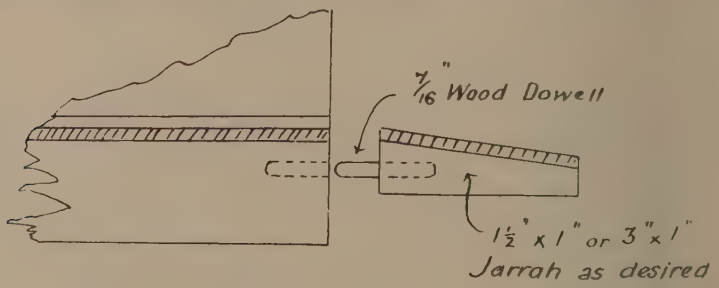


Fig. 9.

Frames.—It is most important that these should all be exact to size. A few beekeepers make their own frames, but unless one has plenty of time and is a good workman with a suitable tool, it is cheaper and better to purchase factory made frames.

The sizes of frames are as follow:—For standard full depth brood chamber or super, 9⅛ inches deep; W.S.P., 7⅛ inches deep; Ideal or Bolton, 5⅜ inches deep; half-depth, 4½ inches deep. All frames have the same length of top bar, viz., 19 inches. Leaflet No. 383 deals with Frames and Combs.

In this leaflet, reference is made to the use of wired foundation. When using this foundation I would recommend the use of frames of the Victorian pattern with single groove in top bar, the foundation being fixed by running in hot wax.

The bottom bar should have a slot running the full length, this allows the foundation to enter the bottom bar and expand downwards, consequently the bees build the comb right down to the bottom bar.

If single wedge top bars are used and pierced bottom bars as advertised in Pender's catalogue, the wires only enter the pierced bottom, the foundation not reaching to the bottom bar, a space has to be allowed for the expansion of the wax, resulting in the foundation not being so firmly fixed, and the probability that the comb may not be brought down to the bottom bar by the bees.

I understand that the bottom bars with full length slots can now be obtained from Pender Bros.

Figure 10.

STANDS.

When possible, it is always best to place hives on stands. In winter the floors keep drier and last longer, and in summer the air can circulate underneath; ants and spiders are not so troublesome, and the hives are easier to work as there is not too much stooping.

A good ant-proof stand is shown in Figure 10, and is fully described in the Leaflet No. 302, which also contains description of a stand made of bush timber.

If migratory beekeeping is practised, and it is not possible to use stands, all floors should be fixed to 3-inch x 1-inch jarrah battens, as shown in Figures 4 and 11, to keep the floor off the damp ground. But cut off short. Figure 11 shows a good combination of a factory-made body with home-made floor and cover. It is cheaper and, in my opinion, better than the complete factory-made hive.

The dial at the side is a device of my own for recording the condition of the hive at the last examination. The figures show the dates, and the letters refer to the condition of the hive. A full description of this device was published in the *Agricultural Journal* for September, 1929.

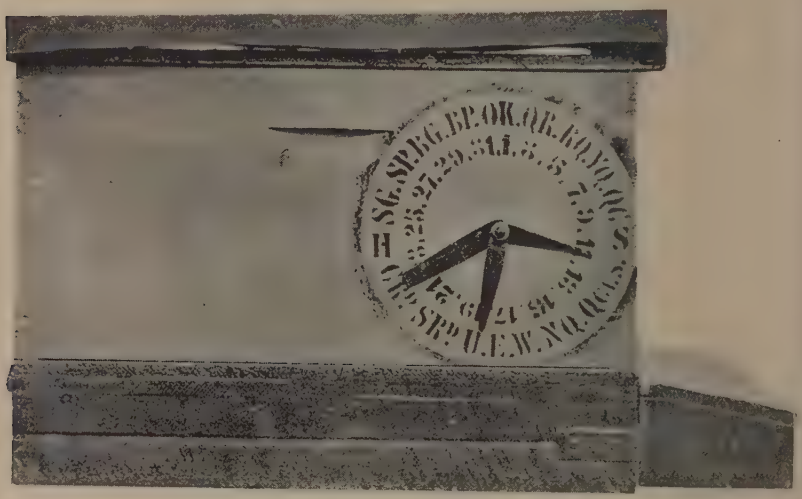


Fig. 11

Painting.

Paint is a very important part of a hive, and much depends on the quality and frequency of painting as to the length of the life of the hive.

All joints should be painted before being put together and nailed, as the joints are usually the first place attacked by the weather. Cement-coated nails should be used whenever possible, as these do not rust and show through the paint like ordinary nails and also hold much firmer. New hives should have two coats at least of good paint before being used; afterwards one coat every second, third, or fourth year, depending upon the quality of the paint used.

As regards the colour, white is that generally used for the whole of the hive, but some bee-keepers who practise migratory bee-keeping and place the hives on the ground, dip the floors in boiling tar or creosote.

There is a tendency at the present time to depart from white and use darker colours. Certainly, a row of clean white hives with a green background looks very neat and attractive. One rarely in these days sees the roof of a house painted white, for the reason that white absorbs heat and passes it through, whereas red throws off the heat rays. Therefore, the roofs of hives should, whether of wood or iron, be painted with red oxide or green or grey asbestos.

Experiments conducted at the Schleswig Holstein School of Bee-keeping on the drifting of bees from one hive to another, show that bees drift most into hives of the same form and colour as their own, that it is exceptional for them to drift from skeps to frame hives or vice versa. It was also shown that bees prefer hives that are painted yellow, blue or dark colours, or that have their fronts or porches of these colours, and that they dislike pale colours, and, above all, pure white.

Notes made on the number of frames occupied by bees at various dates showed that colonies in pale-coloured hives grew weaker, while those in the preferred colour built up.

I do not say that colour is a very important factor, but the above experiments would go to show that it is a factor, and it is worth while for bee-keepers to bear it in mind. It is quite certain that in a large apiary or in a queen-rearing establishment, it is a great advantage to have hives painted different colours to assist the bees in locating their homes.

IRRIGATION HEAD DITCHES.

By A. R. C. CLIFTON, Officer in Charge of Irrigation.

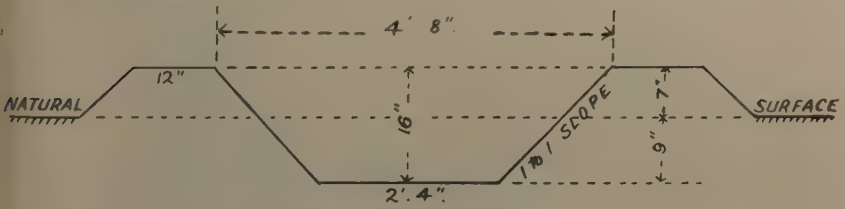
The application of water economically to land for irrigation is incumbent upon the provision of adequate channels or head ditches, and where these are too small or upkeep continues to be neglected after due warning has been given, the Irrigation Commission has decided that water will be refused until the defect has been rectified.

Where head ditches are wrongly located, too small, inadequately maintained, or insufficient ditching has been done, difficulties will occur in applying the water to the land and inefficiency must result.

The farmer, before constructing a head ditch, should apply to the district irrigation office for the local Agricultural Adviser to visit him, so that the ditch can be properly located and the necessary grades, etc., supplied; even after this information has been given, however, the head ditches are frequently made too narrow. The use of an existing drain for irrigating out of is uneconomical and should only be adopted as a very temporary expedient. The object of a drain is to keep water below the surface and depth is the important feature, whereas with an irrigation head ditch the water must be held up so as to get it over the surface of the ground in large quantities, and, therefore, it should be made shallow and, to obtain the carrying capacity, of ample width—just the opposite to a farm drain.

The head ditch leading away from the supply point should have a bottom width of 2 feet and a batter or side slope of 1 to 1, the depth of the finished ditch from the top of the spoil bank to the invert being 16 inches; made up of 9 inches of cut and 7 inches of spoil.

The following is a typical cross section:—



The ditch requires to be properly graded and where the spoil from the centre is insufficient to build up the banks to the required height, due to some slight depression or claypan, the extra spoil necessary should be carted to the spot as it is bad practice to attempt to get this by deepening the ditch in the low places, which causes a weakness at the very place where extra strength is required to minimise the danger of breakaways.

The art in irrigating is to apply the required quantity of water uniformly over the land, but it is not possible to get 100 per cent. even distribution with furrows as the top end of the field generally gets more than the bottom and consequently when the water is turned off, it is necessary to have no water left standing in the head ditch which may cause water-logging of the adjacent land. It is, however, impossible to drain all the water off if low places have been made by attempting to get extra spoil for the banks or for any other reason the ditch is not properly graded and consequently the water has to seep away and may cause that portion of the crop nearest the ditch to get too much water.

Not only is it necessary to have adequate head ditches for efficient watering, but it is also necessary to properly maintain them. Stock do damage by knocking in the banks, weakening the latter and causing silting in the ditch. It is a simple matter to go along the ditch with a shovel the day before the water is due to be turned on each time, and do any touching up required. The amount of spoil or clods that have rolled in may not be much but it is surprising how a few clods and silt here or tuft of grass there will decrease the flow, and it does not matter how clean the ditch is farther on, that decreased flow cannot be made up. The result is inefficient watering and loss of time, for not only must the farmer spend more time attending to the watering when he is probably anxious to get on with other farm work, but delay, which may be serious to some other water user, occurs in getting the water on to neighbouring farms.

Another source of the trouble to the irrigator is the practice of connecting the irrigation furrows direct to the head ditch, necessitating the making of numerous cuts through the banks to let the water out. To prevent this weakening of the ditch and also to simplify the control of the water, a head furrow should be ploughed parallel with the ditch across the top ends of the irrigation furrows. This head furrow serves as a miniature ditch supplying the individual furrows and being supplied from the head ditch at suitable points where necessary along the headland.

Farmers have now been notified of a programme for watering this year which has been worked out so as to enable the controlling authority to render efficient service to the farmers and ensure supplies of water for all. The success of this scheme is most important and necessitates the ready co-operation of the farmers, the district officers of the Department of Agriculture and the Public Works Department.

The water in the main distributories is under the control of the Hydraulic Engineer's Branch of the Public Works Department and when delivered on to the farm that Department has fufilled its contract and it is then the farmer's duty to make the necessary arrangements to handle it efficiently with the advice and assistance of the district officers of the Irrigation Branch of the Department of Agriculture.

Farmers, therefore, who require any information or levels in connection with the irrigation of their land must apply to the local Agricultural Adviser at the district Irrigation Office, who will supply the required information.

These officers are fully occupied in dealing with applications for assistance and any farmer who requires a visit from one of these officers and has not made application, should do so immediately.

THE RUSTS OF CEREALS.*

H. A. PITTMAN, B.A., B.Sc. Agr., Dip. Ed.,
Plant Pathologist.

1.—STEM RUST OF WHEAT AND BARLEY.

(*Puccinia graminis* var. *tritici.*)

Stem Rust, known also as Black or Summer Rust, is a disease resulting from the attacks of a parasitic fungus known as *Puccinia graminis.*

Stem Rust occurs wherever wheat is grown. So serious are the losses resulting from its attacks, that, of all known plant diseases, it is generally considered to be the most important, and more attention has been given to its study than to that of any other of the many ills to which plants are subject.

The occurrence of rust to a serious ("epidemic") extent is closely related to climatic conditions, and, in many countries where such conditions are apt to be favourable, the disease has become a definite limiting factor in the production of wheat for grain. In New South Wales, rust has made the growing of grain on the coastal areas unprofitable, and its outbreak in the early days of the settlement stimulated the exploration and development of the back country.

It is hard to determine the exact amount of loss due to any plant disease, but the following figures will give some idea of the serious depreciation in crop values which rust may cause. It has been estimated that in 1916, in the United States, the disease caused a loss of at least 280,000,000 bushels, which was equivalent to about one-third of the crop. In 1920, in Minnesota (U.S.A.), 60 per cent. of the crop was lost. The epidemic year of 1916 is said to have cost New South Wales more than £2,000,000.

Fortunately, Western Australia suffers less from rust than any other of the Australian States. Serious loss occurs only rarely. In fact, during the last thirty years, on only three occasions has the disease assumed serious proportions—in 1915, 1917 and 1934. Black stem rust assumed epidemic proportions in the northern parts of the wheat belt in 1934, many farmers suffering losses with some varieties amounting to total failure. It was no uncommon thing for yields to be reduced to the extent of 75 to 80 per cent.

The district which suffers most is the Midland-Geraldton-Northampton area which, from its situation near the sea, is more humid than the wheat belt proper. In normal years any loss which occurs from rust is so insignificant as to pass unnoticed, and, indeed, so uncommon is it that considerable difficulty is experienced in obtaining good specimens.

Symptoms.—The first indication of the presence of rust is the appearance, principally on the stems, but also on leaf sheaths and leaves, of elongated reddish-yellow spots. On close examination, these spots will be found to be raised above the surface of the leaf like a small blister. Eventually, the skin bursts, exposing to view a narrow, elongated, powdery, reddish mass surrounded by the ragged edges of the pustule. The apparent resemblance of the latter to iron rust has earned for the disease its popular name. Each of these rusty-looking spots is known as a *pustule* or *sorus.* Under favourable conditions, the pustules rapidly increase in numbers, and may spread to the ears.

* Revised from the article of the same name by W. M. Carne and J. G. C. Campbell published in this Journal for April, 1924, pp. 73-80, and which was subsequently issued as Bulletin 126, owing to the Bulletin referred to being now out of print.

Later in the season the reddish pustules gradually change to black, especially on the stem. From these, the disease derives its name of Black Rust. This stage is known also as Stem Rust and Summer Rust. It should be clearly understood that the black and the red pustules, although different in appearance, are really only different stages of the one fungus, and do not represent two different diseases.

The red pustules are the more plentiful when the plants are green, the black appearing and gradually predominating as they ripen off towards harvest.

Damage done to Crops.—The amount of damage done to the crop is proportional to the number of pustules present, and to the earliness of the attack. If the disease appears while the plants are yet young the result may be serious; if, on the other hand, it does not attack until they approach maturity, the effects may be negligible.

The parasite weakens the plants by causing them to give off more moisture through the leaves than healthy plants, and by utilising the food which otherwise would contribute to their growth and, later, to the formation of the grain. This food can only be obtained by the rust fungus from the living plant cells. In susceptible wheats, the cells are not affected by the presence of the fungus, and go on functioning as usual. In resistant plants, on the contrary, the cells die wherever the parasite attacks, thus cutting off the food supply of the fungus and causing it, in turn, to die of starvation.

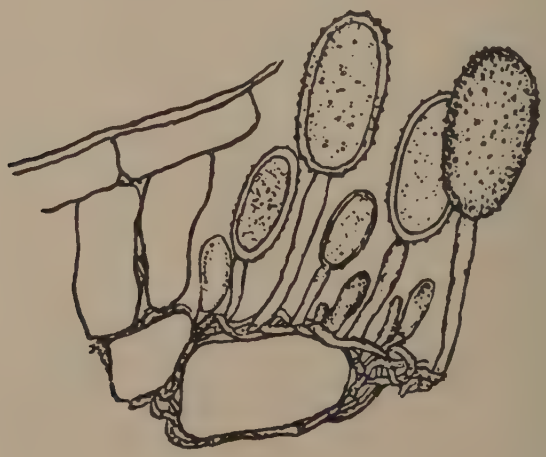


Fig. 1.—Black stem rust of wheat: Clusters of reddish spores (Uredospores) breaking through the skin (*epidermis*) of the leaf. (*After Duggar.*)

The extent of the damage also varies. In the worst cases, the crop may be a complete failure. In rather less severe attacks, the grain, although formed, may be pinched and small, and unsuitable for milling, and the plants may be stunted. The yield of hay is then reduced, although the quality is not deleteriously affected as regards food value. However, the spore dust which arises from it is liable to cause irritation of the nasal mucous membranes of the stock to which it is fed. This may be obviated by previously damping or steaming the fodder.

Life History of the Fungus.—The red rust pustules contain a loose powder, which, in bad attacks, rises like a cloud of dust when the plants are shaken. This powder consists of minute, oval, reddish-brown bodies about one-thousandth of an inch in diameter. These are the spores or seed bodies of the fungus, and are known, technically, as *uredospores* (Fig. 1). They are the cause of the rapid spread of the parasite from one part of the plant to another, or from plant to

Fig. 2.—Black stem rust of wheat: A germinating "uredo-" or "summer"-spore. (*After Duggar.*)

plant. When these uredospores are placed in a drop of water they germinate (Fig. 2), producing one or more thread-like outgrowths which are known as germ-tubes. Under ordinary circumstances, the growing spore now dies. If, however, the water in which it is growing is on a wheat plant, the germ tube enters

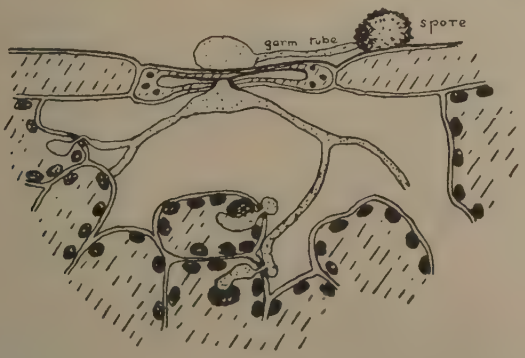


Fig. 3.—Black stem rust of wheat: Infection of leaf by uredospore through breathing-pore on leaf. (*After Osborne.*)

through one of the breathing organs (*stomata*) (Fig. 3) of the leaf or stem, provided these are open at the time, and grows amongst the cells of which the plant is constituted. From these cells it absorbs the food of the plant by means of special absorbing structures called *haustoria,* and flourishes at the expense of the plant, which is now known as *the host.*

After growing in the host for about six to ten days, the fungus is ready to form spores. These are developed just beneath the surface of the stem or leaf, etc. As they mature, the outer layer of cells (*epidermis*) becomes pushed out and, finally, is burst open, exposing to view the reddish spores beneath, and thus forming the typical rust pustule. The spores are blown about by the wind and, eventually, some of them lodge in a film of water on the same or another wheat plant, germinate, and cause infection as just described.

After the pustule opens, spores are continuously formed and distributed. Consequently, new infections are always taking place, and new pustules appearing. The number of spores liberated, and, therefore, the number of new infections, steadily increases as the season advances, provided the weather conditions are favourable, until, finally, the attacks occur so frequently that the plants are unable to maintain themselves against them. The result is a more or less complete failure of the crop.

Fortunately, in Western Australia, suitable conditions occur only occasionally. The essential factor for the spread of rust is moisture, and this must be accompanied by moderately cool to warm temperatures. The disease is most prevalent, therefore, during sultry weather (when the air is charged with moisture), in damp situations, or in periods characterised by frequent light rains or heavy dews, more especially if these are accompanied by a long succession of cloudy or overcast days. A long succession of cloudy mornings, followed by warm, but not hot, days, with occasional showers is very conducive to an epidemic of rust. The humid atmosphere prevents a sufficiently rapid evaporation of the water from the plants, thus giving the uredospores place and time to germinate and enter the host.

The usual freedom of Western Australia from rust in the wheat-growing areas is due to a great extent to the general absence of muggy weather in the spring and early summer. Nevertheless, the little rust which does occur is sufficient to ensure the presence of spores to start an epidemic when favourable conditions do develop during the growing season.

Rust may appear in the autumn or during mild winters, but, usually, it is during the spring and early summer that it is most prevalent.

As the plants begin to ripen off, the red pustules on the stem are replaced by black ones. These black pustules contain spores of another type which, individually, are dark brown in colour, but, in mass, appear black. These spores are larger than the red ones, are two-celled, and are known as *resting spores* or, technically, as *teleutospores*. (Figs. 4 and 5.)

Wheat rust probably originated in a country possessing a cold climate, and the various stages of its life history were developed accordingly. In the colder parts of Europe and North America, the red spores cannot survive the severe winter. The black spores, on the contrary, will not germinate unless they are previously exposed to intense cold. Formed during the summer, or autumn, they lie wherever they fall until the following spring. They then germinate, producing a short germ tube (or *promycelium*) on which are produced four spores of a third type—*sporidia*. These sporidia cannot parasitize wheat plants. They will grow only into a few species of a totally different plant known as the barberry, especially the common barberry—*Berberis vulgaris*. After growing on this plant for a time a fresh lot of spores are formed. They appear on the upper surface of the leaf, and differ in appearance from either of the three types previously described. Spores of this fourth type are known as *spermatia*. They are produced in small

flask-shaped structures, known as *spermogonia,* which are embedded in the tissue of the barberry leaf. These open, in the great majority of cases, on the upper surface of the leaf, over which they exude the spermatia embedded in a sweet spermatial ooze or nectar. Insects such as flies are strongly attracted by the sugary nature of the spermatial ooze, and perhaps also by its odour, and soon bring about a mixing together of the spermatial ooze exuded from different *spermogonia* on the same or different barberry leaves. For many decades after the rest of the life-history of the black stem rust fungus had been worked out by scientists the exact nature and function of the *spermatia* was not understood. As a matter of fact, it was not till J. H. Craigie, of the Government Dominion Rust Laboratory, Winnipeg, Manitoba, Canada, published a short article entitled "Experiments on Sex in Rust Fungi," in "Nature," dated 23rd July, 1927, that the true significance of the spermatial stage became known to the world.

Craigie showed that the *spermatia* represented sex-cells or gametes, and that by the mixing of the spermatial ooze of + (male) and — (female) strains of the fungus, a further stage in the development of the parasite became possible. He showed also the tremendously important fact, from both academic and economic aspects, that it was by the mixing of the spermatial oozes of different biological strains of the rust fungus that entirely new strains of the parasite could be evolved. The production of strains of the rust fungus previously unknown to science, has, in this way, been actually accomplished by Dr. W. L. Waterhouse, of the University of Sydney, Margaret Newton *et al,* and Stakman *et al.** .

Following on the mixing of spermatial ooze from + and — forms of the rust fungus, the fertilised mycelium grows down to the bottom side of the barberry leaf and there produces small cup-like structures known as cluster-cups or *aecidia.* Each *aecidium* produces within it long chains of aecidiospores, these representing the fifth type of spore produced in turn by the rust fungus. These aecidiospores cannot infect barberry plants but readily infect wheat, giving rise to a typical rust lesion which soon produces the red spore or *uredospore* stage of the rust.

This part of the development by means of teleuto- and aecidiospores does not occur in Western Australia, for two reasons. The first is that the barberry does not occur here (except occasionally as a garden shrub); the second is that the temperature is not low enough to give the teleutospores the requisite period of cold. The latter spores, therefore, are of no practical importance under Australian conditions, although Dr. W. L. Waterhouse, of Sydney University, has shown that, under suitable conditions, they will function as they do in cold countries. This he has often done by experimentally producing the characteristic cluster-cups on barberry plants by means of teleutospores from wheat, which has first been exposed to the cold winter of Glen Innes, in the New England District of New South Wales, or other parts of the Tablelands.

How the infection is carried over from season to season.

In Australia, rust usually does not appear before the spring. So far, it has not been satisfactorily explained how the disease survives from harvest to the following spring. Three major methods have been suggested, and each of these has some evidence in its favour.

* Waterhouse, W. L.—"A Preliminary Account of the Origin of Two New Australian Physiological Forms of *Puccinia graminis tritici.*" Proc. Linn Soc. N.S.W. 54, pp. 96-106, 1929.
Newton, Margaret; Johnson, T.; and Brown, A. M.:—"A Preliminary Study on the Hybridisation of Physiological Forms of *Puccinia graminis tritici,*" Scientific Agriculture, Vol. X., No. 11, pp. 721-731, July, 1930.
Stakman, E. C.; Levine, M. N., and Cotter, R. U.:—"Hybridisation and Mutation in *Puccinia graminis* (Abs.)," Phytopathology, Vol. 20, p. 113, 1930.

1. It is possible that sufficient red spores survive in sheltered places to start the disease again when a favourable opportunity occurs. With a short period of suitable weather, these few would quickly reproduce millions; rust again would be in evidence, and would be spread quickly and widely by the wind, which is known to carry spores for many miles.

2. The rust may survive on self-sown, out-of-season wheat or barley. This is more probable in the Eastern States, which have summer rainfall, than in Western Australia, where summer rains are unusual. Sufficient susceptible plants possibly persist, however, in the neighbourhood of soaks and other moist places to ensure a "carry over" for the disease from the hot dry conditions of summer till the following autumn or spring.

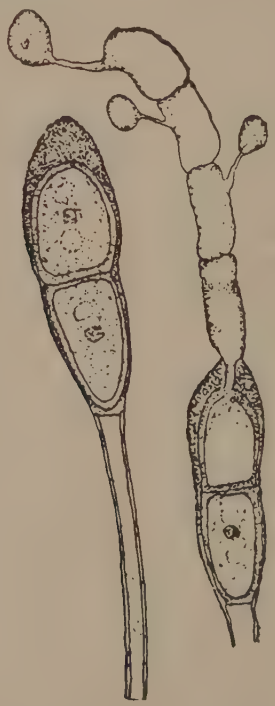


Fig. 4.—Black stem rust of wheat: Teleutospores or "Resting" spores. On the right the two-celled spore is shown after germination with the secondary spores (*sporidia*) growing from three sections of the germ tube. (*After Duggar.*)

3. *Puccinia graminis tritici* attacks other cereals and many grasses. This suggests that these plants may carry over the fungus when wheat is not grown. *Puccinia graminis*, variety *tritici*, will attack wheat, barley, rye and, to a slight extent, certain grasses, such as barley grass, but will not attack oats. The remarks made just above re the importance of soaks and other moist places apply here with equal force.

Control.—In countries where the barberry plays an essential part in the life history of the fungus, the destruction of this plant assists materially in the elimination of the disease. Good examples of this occur in England and Denmark where barberries have been eradicated and black stem rust is now practically unknown.

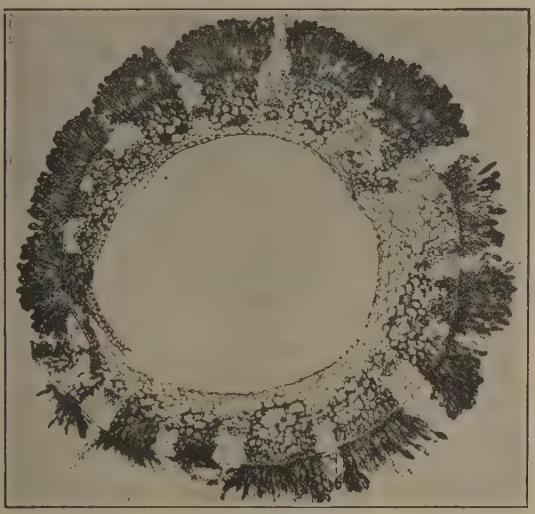


Fig. 5.—Black stem rust of wheat: A cross section of a wheat stem showing "teleuto"-spores formed and the extent of damage on a badly infected plant. (*After N.S. Wales Dept. Agriculture.*)

In Australia, where the barberry does not grow wild, and where it is not essential for the fungus, the problem of control becomes much more difficult. Climate, the principal factor governing an epidemic, is beyond control. No direct method of attacking the fungus which is sufficiently cheap to be economically possible has yet been devised, although in Canada and the United States experiments in which sulphur has been dusted on to the crop from aeroplanes and power dusting machines have been successful. The only practicable method at present known is to grow wheats that will be approaching maturity when the rust is becoming epidemic, or to grow varieties which are resistant to the parasite.

The former of these objects is best attained by growing *early maturing varieties* which, under normal conditions, are sufficiently advanced in growth to be beyond danger of serious damage at the ordinary season for rust. Such wheats include the principal varieties grown in Western Australia, the relatively short season rendering the slower maturing sorts unprofitable. This method is somewhat uncertain, because rust in some years appears unusually early. If these crops are planted still earlier to avoid this possibility, they may fail from premature heading in cold or wet weather.

The growing of wheat only on fallowed land assists to reduce the losses from rust owing to the more vigorous growth of the crop, and the avoidance of crowding of the growth of the wheat with weeds.

Low rates of seeding are of advantage inasmuch as they result in less dense crops.

Liberal application of superphosphate is beneficial in building up resistance and hastening maturity. The sooner the wheat matures the less are the losses from rust. Wheat grown on very rich or very moist land may suffer severely owing to delayed maturity.

The most certain way of avoiding injury from rust is to use resistant varieties of wheat. Since the time of Farrer, of New South Wales, wheat breeders the world over have been devoting special attention to the production of such varieties. Their efforts so far have been only partially successful, as it was found that varieties which, in one place, were resistant would be in another place highly susceptible. The explanation of this behaviour has been found in recent years, by Professor E. C. Stakman and his colleagues, of Minnesota, U.S.A. These investigators have shown that *P. graminis* var. *tritici* consists of a number of strains, each of which attacks only certain varieties of wheat; and that a wheat which is resistant to one strain is not necessarily resistant to any other. These strains are known as *biologic forms.* Over one hundred of these have been isolated in America, and about eleven so far in Australia. In breeding a resistant wheat for a given district, it is essential, therefore, to know the forms of rust that exist there, and to select the plants which resist these. This involves the determination of the distribution of the forms. This is being done, for Australia, by Dr. W. L. Waterhouse, of Sydney University. So far, only two forms are known from this State; namely forms 34 and 43.

The writer's experience during the 1934-35 wheat season in Western Australia indicated the following varieties to be very susceptible to black stem rust:—"Bencubbin," "Ranee," "Glucub," "Canberra," "Totadgin," "Bena," "Geeralying," "Waratah," "Merredin," and "Yandilla King."

The following wheats were noted to be less seriously affected:—"Nabawa," "Comeback," "Gluyas Early," "Sutton," "Sword," "Ford," "S.H.J.," and "Carrabin." "Noongar" usually escaped uninjured owing to its extreme earliness.

It was not possible to make a systematic survey of the position as affecting the varietal susceptibility of all varieties grown in the State.

Owing to the very infrequent development of black stem rust in Western Australian wheat crops, it was not possible for this Department, prior to 1935, to systematically test out the relative susceptibility of the various varieties already in cultivation, or of new varieties released from the Government Experiment Farms from time to time.

Steps have now been taken, however, to establish a "rust garden" at the Merredin Experiment Farm, in which it will be possible artificially to create rust epidemics, so that the relative status of the different varieties being grown in this State, so far as susceptibility or resistance to rust is concerned, will be determinable for future guidance.

2.—STEM RUST OF OATS.

(*Puccinia graminis* var. *avenae.*)

This disease occurs in the South-West of the State, but is by no means as serious as the Stem Rust of Wheat. It occurs both on cultivated oats and on wild Black oats.

3.—LEAF RUST OF OATS.

(*Puccinia lolii-avenae.*)

This is common both on cultivated and on Black oats. The damage done does not appear to be very serious. It is essentially a leaf disease, even the black teleutospores being formed on the leaves.

4.—LEAF OR SPRING RUST OF WHEAT.

(*Puccinia triticina.*)

This disease occurs in the coastal areas of Western Australia. It is common in the Eastern States, but it is not considered to be as serious as the Stem Rust. The pustules occur principally on the leaf blades.

5.—LEAF RUST OF BARLEY.

(*Puccinia simplex.*)

This disease has not been recorded for Western Australia up to date.

The life histories of the Leaf Rusts do not differ, generally, from that of the Stem Rusts.

The secondary host for Wheat Leaf Rust is Meadow-rue (*Thalictrum* spp.); for Oat Leaf Rust it is Buckthorn (*Rhamnus* spp.). These plants take the place of the barberry in Stem Rust. The aecidial stages are, however, not known in Western Australia.

OATS IN THE WHEATBELT.

R. P. Roberts, Agricultural Adviser.

In Western Australia cereal production the oat crop occupies a secondary position, though one which, at present, is of increasing importance. The predominance of wheat in the State's agriculture is accounted for by the large overseas market which exists for that commodity and which has been responsible for the development of most of the farming lands in the lower rainfall districts of the south-west division of the State.

There is no similar world market for oats which, consequently, are grown either for the limited home market or, more commonly, for consumption on the farm on which they are produced, as hay, silage, or grain for stock.

The decline in wheat prices during the past five years has forced farmers to specialise less in wheat production and attempt to develop other sources of revenue. In the drier areas of the wheatbelt this invariably means that more attention is paid to sheep, the number of which has shown a considerable increase in the wheatgrowing districts in recent years. This shifting of interest from wheat to sheep, together with an increased demand for horse feed due to the swing back from tractors to horses, has led to an extension of the area sown to oats. This is shown in Table 1.

TABLE 1.

Year.	1928.	1929.	1930.	1931.	1932.	1933.	1934.
Area sown to Oats ... (acres)	584,081	691,094	551,121	514,394	588,337	689,561	801,570

With the onset of the depression in 1929 the area sown to oats declined during the next two years, but since 1931 there has been a steady increase. In 1930 the area sown to oats was only 13 per cent. of that sown to wheat; in 1934 it was nearly 28 per cent.

It should hardly be necessary to stress the importance of farmers who run sheep making adequate provision for carrying their stock through the lean period during the late summer and autumn months. For this purpose, oats are well suited. Even where it is not desired to increase carrying capacity, farmers could often, with advantage, grow a little more oats and a little less wheat each year.

Although oats do best in a cool moist climate, there is practically no district in the wheatbelt in which they cannot be grown providing the right variety is chosen. They will grow on practically any soil in which wheat can be grown and will sometimes produce a crop on types of soil in which wheat fails. Oats are very suitable for early green feed and are highly valued for hay, while the grain is one of the best and safest feeds for stock.

Unlike wheat, oats are not rendered liable to diseases such as Septoria through coming into ear too early in the season, consequently it is possible, and in fact, with some varieties the usual practice to sow them before a start is made with the seeding of the wheat crop. A further very desirable characteristic of oats is that they are not liable to fungous diseases such as root rot and take-all, which attack wheat, and consequently are a very useful crop to use in a rotation to assist in the control of these diseases.

In addition to their many good points, oats have one or two characteristics which, from the agricultural point of view, are very undesirable. Most varieties lodge, some of them very badly. However, as there are a number of comparatively strong straw varieties in existence, this is a fault which can be partly, is not entirely, eliminated in time. A worse fault is shattering. No commercial variety is known which holds its grain well, though some are better than others in this respect. A few hours of strong wind is likely to cause serious loss of grain in a ripe oat crop. The actual loss due to this is minimised considerably when sheep are carried, as much of the grain will ultimately be picked up from the ground by them when feeding, but the liability to shattering does set limits on the acreage that can safely be handled on any particular farm. Fortunately, a start can be made with harvesting operations before all the oats in the panicle are properly ripe as the moisture from the green oats is absorbed by the dry grain.

Of the area sown to oats in 1934, 137,459 acres or 18 per cent. was utilised for green feed, 252,388 acres or 31 per cent. was cut for hay, while the remaining 411,723 acres or 51 per cent. was stripped for grain.

The acreages and average yields per acre of the oats stripped for grain during the past seven years are given in Table 2.

TABLE 2.

Year.	1928.	1929.	1930.	1931.	1932.	1933.	1934.
Area ... ... (acres)	325,827	385,134	274,874	267,894	285,850	342,642	411,723
Average Yield per Acre (bushels)	10·9	10·5	11·98	13·25	12·61	11·53	10·46

(*To be continued.*)

METEOROLOGICAL INFORMATION.

STATIONS.	TEMPERATURE.				RAINFALL.		TEMPERATURE.				RAINFALL.		TEMPERATURE.				RAINFALL.	
	Maximum.		Minimum.		For Month.	Average.	Maximum.		Minimum.		For Month.	Average.	Maximum.		Minimum.		For Month.	Average.
	Mean.	Highest.	Mean.	Lowest.			Mean.	Highest.	Mean.	Lowest.			Mean.	Highest.	Mean.	Lowest.		
	JUNE, 1935.						JULY, 1935.						AUGUST, 1935.					
					inches.	inches.					inches.	inches.					inches.	inches.
Chapman State Farm	67·9	79·5	46·0	40·2	1·17	4·27	65·8	75·6	43·5	35·8	3·32	3·95	66·8	79·4	44·5	38·3	3·26	2·78
Geraldton	68·5	78·1	51·9	41·5	2·48	4·79	66·8	71·8	51·7	45·0	3·21	3·90	68·1	82·6	51·6	43·0	3·29	2·88
Walebing	62·7	75·5	42·8	32·0	1·65	4·04	61·3	71·0	41·0	32·5	3·79	3·77	63·0	73·3	41·5	33·6	3·41	3·11
Perth	63·7	78·0	49·2	40·8	4·13	7·08	62·5	66·7	48·1	40·0	10·61	6·73	64·6	77·4	47·5	37·5	3·97	5·73
Kalamunda	60·3	73·5	47·6	39·5	3·76	8·34	58·1	64·0	45·9	39·0	11·61	8·57	61·5	74·0	46·5	38·0	5·25	6·91
Bunbury	63·1	71·1	46·5	35·4	5·46	7·14	61·5	66·0	48·4	36·4	9·62	6·80	62·6	69·0	46·2	35·8	3·78	5·27
Bridgetown	60·5	75·0	38·8	26·5	4·97	6·04	58·7	64·0	39·3	32·2	9·49	5·87	63·3	78·0	37·4	28·5	4·66	5·09
Albany	61·3	73·0	47·9	42·4	6·12	5·49	59·6	67·0	45·7	36·0	10·60	5·61	62·3	78·1	45·3	40·0	3·85	5·30
Merredin State Farm	62·4	75·5	42·5	31·5	·74	1·87	60·4	70·1	41·2	32·0	2·03	1·89	62·8	80·8	40·0	32·0	2·18	1·52
Northam	63·5	76·0	46·0	37·2	2·05	3·30	62·5	71·6	41·2	33·0	3·50	3·49	64·5	79·0	40·6	33·0	2·70	2·60
York	62·5	75·0	43·0	34·0	1·96	3·32	61·5	70·3	41·9	32·0	3·82	3·42	63·7	78·0	39·9	32·0	3·36	2·81
Narrogin State Farm	59·0	68·8	41·9	34·3	2·81	3·65	56·3	63·5	40·9	31·6	6·07	4·18	59·5	74·4	40·1	31·3	3·69	3·75
Katanning	58·5	69·3	42·2	33·3	2·56	3·01	56·7	63·2	41·7	32·2	3·94	3·09	59·1	74·0	40·4	31·0	2·36	2·47
Cape Leeuwin ...	60·4	74·0	52·2	40·0	6·92	7·12	60·3	67·0	52·4	46·5	7·51	7·34	61·8	74·5	51·0	43·0	4·65	5·31

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No. 427.—*Grade Herd Recording, W.A.,* 1934. G. K. Baron-Hay.
No. 428.—*Malting Barley.* R. P. Roberts.
No. 429.—*Mediterranean Fruit Fly.* L. J. Newman.
No. 430.—*Effect on Body Weight and Wool Growth of Feeding Sulphur to Sheep.* E. J. Underwood.
No. 431.—*The Lamb for Export.* Geo. L. Sutton, I. Thomas, and N. Davenport.

The following publications may be obtained from the Department of Agriculture, Perth, on application, or will be sent post free to any address in this State on receipt of a remittance for the amount stated :—

The Management of Poultry under Western Australian Conditions, by W. T. Richardson, Poultry Adviser :

This is a most useful and valuable book, not only for beginners, but to all those who keep fowls for pleasure and profit. It deals fully with all matters connected with the industry, including Breeding, Feeding (for stock birds or egg production), Incubating, Brooding and Care of Chicks, Marketing (eggs and poultry), and all matters of use to the poultry-keeper. It also fully describes symptoms of various ailments and diseases and simple treatment for same, and, as the book was written to suit *local conditions*, every poultry-keeper should have a copy by him. Price, 2s.

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This publication contains numerous illustrations, being reproduction of photographs taken in this State, of pruned and unpruned trees, which make the details set out in the letterpress particularly easy to understand. Price 2s. 6d.

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